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RESEARCH AND DEVELOPMENT FACILITIES
TASK GROUP Final Report (NASA)
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Space Research and Development Facilities Task Group

Volume 5

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*Volume 5 – Space Research and Development Facilities Task Group***Table of Contents**

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1. The first part of the document is a list of the names of the persons who have been appointed to the various positions of the Board of Directors of the Corporation.



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Section I

EXECUTIVE SUMMARY**I.A Introduction**

With the beginnings of the United States (U.S.) space program, there was a pressing need to develop facilities that could support the technology research and development, testing, and operations of evolving space systems. In a past era of rapid growth and the focused pursuit of diverse national aerospace goals – including in the 1960s the nearly simultaneous development of major systems such as Intercontinental Ballistic Missiles (ICBMs), the Apollo program, and telecommunications satellites – there were clear advantages to the U.S. in having access to a large number of similar facilities for the conduct of space research and development (R&D). Over time, however, a significant number of these once major program-driven facilities have become ‘institutionalized.’ Moreover, as the U.S. enters the new 1990s era of fiscal constraint in both military and civilian space efforts, fewer new space system development programs are being started and many ongoing programs are being canceled or redefined. Redundancy in facilities that was once an advantage in providing flexibility and schedule accommodation is instead fast becoming a burden on scarce resources. As a result, there is a clear perception in many sectors that the U.S. has many space R&D facilities that are under-utilized and which are no longer cost-effective to maintain. At the same time, it is clear that the U.S. continues to possess many space R&D facilities which are the best – or among the best – in the world. In order to remain world class in key areas, careful assessment of current capabilities and planning for new facilities is needed.

The National Facility Study (NFS) was initiated in 1992 to develop a comprehensive and integrated long-term plan for future aerospace facilities that meets current and projected government and commercial needs. The study was conducted with participation by the National Aeronautics and Space Administration (NASA), the Department of Defense (DoD), the Department of Commerce (DOC), the Department of Energy (DOE) and the Department of Transportation (DOT). The NFS consisted of three major Task Groups:

- Aeronautics Task Group
- Space Operations Task Group
- Space Research and Development (R&D) Task Group

A fourth group, the Engineering and Cost Analysis Task Group, was subsequently added to provide cross-cutting functions, such as assuring consistency in developing an inventory of space facilities.

The final report of the NFS is organized in five volumes:

- Volume 1 a report on the computerized inventory that was developed for the NFS
- Volume 2 the Aeronautics Task Group final report
- Volume 3 the Mission and Requirements Model used by the Space Operations and Space R&D task groups
- Volume 4 the Space Operations Task Group final report
- Volume 5 the Space R&D Task Group final report

This document, Volume 5 of the NFS report, is the final report of the Space R&D Task Group and is organized along the following lines:

- Section I
Executive Summary, provides principal findings and recommendations of the study, as well as key actions needed and estimated schedules to complete.
- Section II
Introduction, provides discussions of the methodology used, and evaluation criteria applied in assessments.
- Section III
Working Group Reports, provides definitions of categories of facilities and recommendations, as well as the actual findings and recommendations of the study, laid-out according to those definitions.
- Section IV
General Findings and Recommendations, covers broad or common topics, such as issues associated with management of test facilities, prioritization of recommendations, the impact of requirements excursions on findings, and where subsequent efforts should be focused.
- Section V
Definition of Terms used, including abbreviations and acronyms.
- Section VI
List of figures and tables

In addition, appendices document the study Terms of Reference, participants, references, and provide additional working group information.

I.B Space R&D Facilities Study Overview

In order to assess the nation's capability to support space research and development (R&D), a Space R&D Task Group was formed. The Task Group was co-chaired by NASA (by Dr. Peter Lyman) and DoD (by Mr. Dennis Granato). Membership included representatives from several of the services and agencies of the DoD (Army, Navy, Air Force, and the Ballistic Missile Defense Organization, BMDO), NASA (MSFC, LeRC and Headquarters), DOC, DOE, and DOT.

The Task Group formed four major, technologically-/functionally- oriented working groups with co-chairs from NASA and DoD. These were:

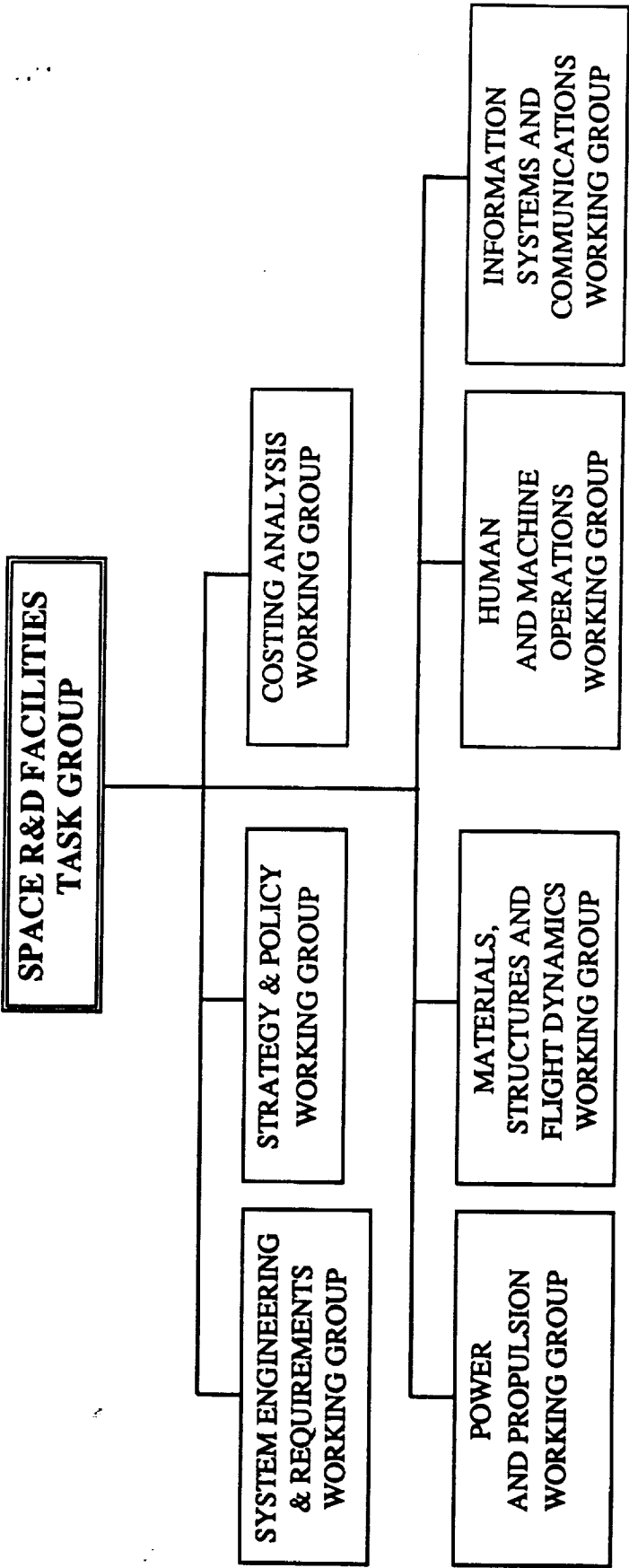
- Human and Machine Operations
- Information and Communications
- Propulsion and Power
- Materials, Structures and Flight Dynamics

In addition to these groups, three supporting working groups were formed:

- Systems Engineering and Requirements
- Strategy and Policy
- Costing Analysis

Figure 1 depicts this organizational structure.

FIGURE 1 – NATIONAL FACILITIES STUDY
SPACE RESEARCH AND DEVELOPMENT TASK GROUP



The working groups were comprised of individuals who had expertise in a particular functional area and did not necessarily include representatives from all organizations represented by the membership of the Task Group. Overall, the working groups identified and collected data on over 500 facilities, including NASA and Air Force, and a limited number of Army, Navy and industry facilities. (The task group did not consider foreign facilities). Since the facility inventory was not as complete as necessary in the view of the task group, the working groups were authorized to augment the inventory through personal knowledge where needed. It is felt that this combination included most of the major U.S. facilities involved in space R&D. Classified space R&D facilities were treated separately.

I.C Principal Findings and Recommendations

The Space R&D Task Group examined several hundred facilities against the template of a baseline mission and requirements model (developed in common with the Space Operations Task Group) and a set of excursions from the baseline. The model and excursions are described in Volume 3 of the NFS final report. In addition, as a part of the effort, the group examined key strategic issues associated with space R&D facilities planning for the U.S., and these are discussed in Section IV. The following are the principal findings and recommendations of this study.

I.C.1 Principal Task Group Findings

Several significant findings and conclusions resulted from the effort. These included:

- The baseline mission model projected for the next 30 years requires only one new facility. For almost all excursions, the unique facility needs could be met through upgrades and/or modifications to existing facilities.
- During this period of dramatic downsizing of all participating departments and agencies, the roles and missions of the agencies as currently establishes have, in some case, produced overlap of functions and responsibilities. This was a limiting factor in defining some facility improvements or savings/decommissioning.
- There is an over-capacity in some areas of government-owned space R&D facilities. Consideration of the industry side magnifies the problem.
- A comprehensive aerospace facility inventory is required. The inventory developed for the NFS is incomplete and contains inconsistencies, but it provides a good foundation.
- Significant savings associated with facility closure and/or consolidations can be realized only through reductions in personnel associated with those facilities.
- Space R&D facilities encompass a wide range of types and costs; a number of them have non-space R&D applications potential (with space being the secondary use).
- The total cost of a program which a given facility supports is typically greater (e.g., an order-of-magnitude) than that facility's development, operations and maintenance costs.
- Proper balance of reliance between government and industry will have a significant impact on future facility decisions.

- Significant inter- and intra- agency non-uniformity in usage pricing exists. This leads to confusion for industry and hinders effective utilization of the national facility base.

Table 1 summarizes the size of the total inventory of Space R&D facilities and indicates those selected for analysis by the working groups. Concentration was focused on those facilities believed to be most likely to generate significant recommendations. The facilities recommendations were then grouped into three categories: Category 1 urging specific actions (1A) or no change (1B), Category 2 recommending additional study, and Category 3 facilities which were felt to be too small for study at this time or for which insufficient information was available to make any recommendation. Detailed definitions of these categories are provided in Section III.

I.C.2 Key Task Group Recommendations

The Space R&D Task Group's major recommendations include both strategic issues and specific facilities. At the strategic level, the recommendations address (1) U.S. Space Roles and Functions; (2) Uniform Pricing Policy; (3) Identification of Key National Technologies; and (4) Determination of Non-Space Facility Utilization Opportunities.

U.S. Space Functions and Responsibilities. The participating Agencies should conduct a review of their functions and responsibilities in space activities. This review should include functions and responsibilities of (1) major organizations within each Agency, (2) Agencies in their entirety, and (3) the respective functions of government and private industry. Such a review could provide the basis for significant reduction in U.S. government costs through reductions in facilities, personnel, and programs by reducing the space mission overlap that currently exists within and between Agencies and by clarifying the respective roles of government and private organizations.

One approach would be for the Secretaries of Commerce, Defense, Energy and the NASA Administrator to review space roles and functions within and across DOC, DoD, DOE, and NASA and with industry. The objective is to eliminate overlaps and clarify respective responsibilities to both allow more significant reduction/consolidation in facilities, people and programs and to facilitate the most cost-effective execution of the several agencies' statutory missions.

Uniform Pricing Policy. The Aeronautics and Astronautics Coordinating Board (AACB) should be tasked to conduct a review of pricing policies and practices of DoD, DOE, DOC, and NASA for the use of their space R&D facilities by government agencies and the U.S. private sector. The objective is to develop a uniform policy that removes the existing barriers to the most cost-effective commercial and interagency shared use of U.S. government facilities.

Identification of Key National Technologies. A list of key technologies is needed as the context for any thorough review of U.S. space facility needs, especially for recommending major investment. This list should include military, civilian government and commercial space technologies, as well as key dual-use technologies. The development of such a list would focus government and industry investment and development efforts, allowing clarification of government and private organizational roles – and enabling potentially significant cost savings (see Space Functions and Responsibilities recommendation above).

**TABLE 1 – NFS FACILITY INVENTORY
SPACE RESEARCH AND DEVELOPMENT TASK GROUP**

	INVENTORY				SELECTED FOR ANALYSIS			
	NASA	DOD	OTHER	TOTAL	NASA	DOD	OTHER	TOTAL
POWER AND PROPULSION	46	30	27	103	46	30	27	103
INFORMATION SYSTEMS AND COMMUNICATIONS	59	21	104	184	43	11	103	157
HUMAN AND MACHINE OPERATIONS	111	38	0	149	94	32	7	133
MATERIALS, STRUCTURES AND FLIGHT DYNAMICS	86	22	124	232	84	19	1	104

Determination of Non-Space Utilization Opportunities. Increasing the value of the U.S. federally-supported R&D infrastructure to the tax-paying public is a key technology policy issue. Although the primary motivation for developing and maintaining space R&D facilities must always remain the missions for which they were conceived, nevertheless, the question of dual-use also applies to space R&D facilities. A study is needed to examine the NFS inventory with the goal of identifying opportunities for making U.S. space R&D facilities and capabilities available for the benefit of the U.S. economy through means such as Cooperative Research and Development Agreements (CRDAs), Space Act Agreements (for NASA), and cooperative agreement programs under Chiles' Act.

Specific major recommendations—classified as Category 1A, 1B and 2— affect a wide variety of facilities that span the four technologically-oriented Space R&D working groups.

Category 1. Table 2 provides a summary of Space R&D Task Group Category 1A facilities recommendations and implementation cost impacts. These recommendations include:

- Consolidate the 300/400 Area at the White Sands Test Facility (WSTF) by taking the 300 Area out of service (also known as "downmoding"); this will result in a potential savings of \$1 million/year.
- Consolidate the eight U.S. liquid propulsion High Pressure Component (turbopump) Test capabilities down to two or three, and stop funding on currently planned improvements until decisions are made regarding the specific approach to this consolidation; this will result in a substantial savings (details to be determined by specific planning).
- Accelerate availability of the Human-Rated Life Support facility at the NASA Johnson Space Center by two years.
- Consolidate all USAF space structures R&D facilities at Phillips Laboratory; this will save \$4 million in non-recurring costs as well as \$400 thousand/year in recurring costs.
- Construct a needed new facility for processing composite materials and structures; this will cost \$15 million for implementation.
- Maintain the current schedule for completion and outfitting of the *DECADE* facility at the Arnold Engineering Development Center (AEDC).

Category 2. The facility issues contained in the group's Category 2 recommendations may offer additional opportunities for savings, but require further study and/or other actions prior to implementation. The more significant of these recommendations include:

- Conduct a joint government/industry study to determine which two or three liquid propulsion High Pressure Component (Turbopump) Test facilities should be retained.
- Reactivate/upgrade hybrid rocket motor test facilities.
- Consolidate existing human acceleration facilities into a single, world-class advanced motion effects center by 2010.

TABLE 2 – FACILITY RECOMMENDATIONS/ENDORSEMENTS
(CATEGORY 1A)

	NUMBER RECOMMENDED	TOTAL IMPLEMENTATION COST - \$.M	ONE-TIME SAVINGS/ COST AVOIDANCE (\$.M)	TOTAL ANNUAL SAVINGS/COST AVOIDANCE (\$.M)
POWER AND PROPULSION	4	2	N/A	36
INFORMATION SYSTEMS AND COMMUNICATIONS	3	75	N/A	6
HUMAN AND MACHINE OPERATIONS	1	2	N/A	0
MATERIALS, STRUCTURES AND FLIGHT DYNAMICS	5	37	4	4
TOTAL	13	116	4	46

- Reactivate/upgrade large liquid oxygen/hydrocarbon/tri-propellant rocket engine test facilities.
- Conduct a joint government/industry study to reduce the number of active large thermal vacuum chambers and defer construction of any new large thermal vacuum chambers pending this review.

I.C.3 Integrated Recommendation Cost Impacts

Table 3 provides an integrated look at the detailed costs of all Category 1A and Category 2 recommendations.

I.D Task Group Results

The following paragraphs provide the key findings from each of the working groups.

I.D.1 Propulsion and Power Working Group

Overall, existing power and propulsion R&D and internal government production facilities are adequate to meet the needs of the baseline space mission requirements model. In the excursions, existing facilities are adequate with the exception of development of nuclear propulsion systems for deep space exploration applications. To meet those needs, the working group identified the need for significant facilities investments. In addition, two areas for consolidation were found to be possible, including Space Shuttle propulsion testing at the White Sands Test Facility (WSTF) and high-pressure component (turbopump) test capabilities. The working group also concurred in the 'downmoding' of one or more large single engine test stands at the NASA Stennis Space Center that is currently planned by NASA. Several areas were identified as needing further study (Category 2), including a national high-pressure component test facility, large hydrocarbon tri-propellant R&D facilities, and large hybrid booster facilities. Additional observations included the following:

- There must be continuing national oversight of major propulsion and power facility investments (a healthy tension between a national view and the program manager's view is needed).
- There is a need for an industry/government forum to establish policy for siting large, expensive national facilities.
- There are some excess large propulsion facilities.
- Few large power facilities exist (no redundancy).
- Major investments and considerable lead time (e.g., 15 years) are required to support nuclear propulsion R&D (needed for the Mars mission requirements excursion).
- There is a need for standard/fair pricing policies for the use of facilities.

**SPACE R&D FACILITY TASK GROUP
SUMMARY OF RECOMMENDATIONS**

TABLE 3A

Rec #	Working Group	Agency	Facility Description	Facility Location (State)	Recommendation	Cat	Implem. Cost	Comment	One-Time Savings or Cost Avoidance	Cost Avoidance / Savings per year	Date Savings Start
CATEGORY 1A TOTALS											
1	IC	NASA	Mirror Refurbishment Building	CA	Maintain plan to end mirror refurbishment work	1A	TBD			\$46.6M	1995
2	IC	DOD	DECADE Facility	TN	Maintain scheduled construction and outfitting	1A	\$75.0M			\$0.0M	
3	IC	NASA/DOD	40 different Antenna Test Facilities		Space Technology Interdependency Group should screen new antenna test facilities construction or upgrade	1A	\$0.0M			\$6.3M	
4	PP	NASA	WSTF 300/400 Propulsion Areas	NM	Concur with Shuttle test consolidation/downmode of 300 area	1A	\$1.5M			\$1.0M	1996
5	PP	NASA/DOD	Test Stand (TS) 116 at MSFC, TS 2A at Phillips Lab, CTF at SSC, Pratt's TS E-8	AL, MS, FL, CA	Consolidate High Pressure Component (Turbopump) test capability	1A	TBD			TBD	
6	PP	NASA	A-2 and A-1 test positions at SSC	MS	Concur with SSME Project plans to downmode A-2 by mid-1993 and A-1 by mid-1997	1A	\$0.0M			\$35.0M	
7	PP	NASA/DOD	Nuclear Thermal Propulsion & Specialized Support Test Facilities (Dependent on excursion)	TBD	Invest in new facility	1A	TBD			TBD	
8	HMO	NASA	Human-rated Life Support Test Facility	TX	Accelerate completion of the Human-rated Life Support Test Facility	1A	\$2.0M			\$0.0M	
9	MSFD	DOD	USAF Space Structures R&D Facilities		Continue with AP consolidation as planned	1A	\$15.0M		\$4.0M	\$0.4M	1994
10	MSFD	NASA	KC-135 and DC-9		Retire high time aircraft and replace with low time	1A	\$2.0M			\$3.8M	1994
11	MSFD	NASA/DOD	Facility for processing composite materials and structures	TBD	Provide the US with a national facility capable of high energy or x ray processing / curing of composite materials	1A	\$15.0M			\$0.0M	
12	MSFD	NASA/DOD	1-meter cold optics development lab	TBD	Develop a 1-meter cold optics development laboratory	1A	\$5.0M			\$0.0M	
13	MSFD	NASA/DOD	Liquid Hydrogen Structural Test Facility		Endorse Aeronautics Task Group recommendation to build a new facility	1A	\$25.0M			\$0.0M	

IC - Information and Communications Working Group
 PP - Power and Propulsion Working Group
 1A - Full & Complete Recommendation Should be Implemented

HMO
 MSFD

- Human and Machine Operations Working Group
 - Materials, Structures & Flight Dynamics Working Group

**SPACE R&D FACILITY TASK GROUP
SUMMARY OF RECOMMENDATIONS
TABLE 3B**

Rec #	Working Group	Agency	Facility Description	Facility Location (State)	Recommendation	Cat	Implem. Cost	Comment	One-Time Savings or Cost Avoidance	Cost Avoidance /Savings per year	Date Savings Start
CATEGORY 2 TOTALS											
1	PP	NASA/DOD	Test Stand (TS) 116 at MSFC, TS 2A at Phillips Lab, CTF at SSC, Pratt's TS E-8	AL, MS, FL	Select site for High Pressure Component (Turbopump) test capability	2	TBD			TBD	
2	PP	NASA/DOD	Test Stand (TS) 1A @ Phillips Lab, TS F-1 @ MSFC, TS B-1 @ SSC	CA, AL, MS	Reactivate/upgrade large oxygen/hydrocarbon/hydropropellant rocket engine test facilities	2	TBD			TBD	
3	PP	NASA/DOD	Hybrid Rocket Motor Testing	TBD	Identify an appropriate mix of facilities to cover hybrid rocket motor testing needs	2	TBD			TBD	
4	HMO	NASA/DOD	Acceleration Facilities	TBD	Develop a plan to replace existing acceleration facilities with an advanced motion effects R&D Center by 2010	2	TBD			TBD	
5	HMO	NASA	Crop Growth Research Facilities	CA, TX, FL	Review current facilities for possible consolidation	2	TBD			TBD	
6	HMO	NASA	Controlled Environmental Test Chamber	CA	Review planned man-rated chamber capability for potential consolidation	2	TBD			TBD	
7	HMO	DOE/NASA/DOD	Space Radiation Effects Facility		Conduct a study to determine requirements and assess alternatives	2	TBD			TBD	
8	MSFD	NASA/DOD	Thermal Vacuum Chambers		Convene a special study to examine what duplication of Thermal Vacuum Chambers could be eliminated	2	TBD			TBD	
9	MSFD	NASA/DOD	Spacecraft Integration Facilities		Convene a special study to examine what duplication of Spacecraft Integration facilities could be eliminated	2	TBD			TBD	

IC - Information and Communications Working Group
PP - Power and Propulsion Working Group
HMO - Human & Machine Operations Working Group
MSFD - Materials, Structures & Flight Dynamics Working Group

2 - Recommendation Requires Further Study

**SPACE R&D FACILITY TASK GROUP
SUMMARY OF RECOMMENDATIONS
TABLE 3C**

Rec #	Working Group	Agency	Facility Description	Facility Location (State)	Recommendation	Cat	Implem. Cost	Comment	One-Time Savings or Cost Avoidance	Cost Avoidance / Savings per year	Date Savings Start
CATEGORY 1A TOTALS											
1	All	NASA/DoD/ DOE/DOT/ DOC	Space Facilities Inventory	NA	Develop and maintain an interagency aerospace facilities database.	1A	TBD			\$0.0M	
CATEGORY 2 TOTALS											
1	All	NASA/DoD/ DOE/DOT/ DOC	U.S. Space Functions and Responsibilities	NA	Jointly review overlapping functions and responsibilities	2	TBD				
2	All	NASA/DoD/ DOE/DOT/ DOC	Uniform Pricing Policy	NA	Develop uniform pricing policy and guidelines for use of government space R&D facilities by other governmental agencies and U.S. industry	2	TBD				
3	All	NASA/DoD/ DOE/DOT/ DOC	Key National Technologies	NA	Identify key technologies as well as key dual-use technologies to guide U.S. government facility investment and planning	2	TBD				
4	All	NASA/DoD/ DOE/DOT/ DOC	Dual-Use/Technology Transfer Programs	NA	Proactively identify opportunities for making available to non-government organizations for the benefit of the U.S. economy	2	TBD				
5	All	NASA/DoD/ DOE/DOT/ DOC	Mission and Requirements Model	NA	Maintain NFS mission and requirements model and update annually	2	TBD				
6	All	NASA/DoD/ DOE/DOT/ DOC	Space Facilities Coordination Panel	NA	Establish a national space facilities coordination panel to provide an interagency perspective to facilities decisions	2	TBD				

1A - Full complete recommendation should be implemented

2 - Recommendation requires further study

I.D.2 Materials, Structures and Flight Dynamics Working Group

In general, current materials, structures and flight dynamics R&D facilities were found to be adequate to meet the needs of the baseline NFS requirements model. Several specific facilities were identified as being unique national facility assets.

The working group selected candidate facilities from the NFS inventory that fit into the groups described above. Both government and commercial facilities were evaluated. Many of the facilities initially considered by the working group were primarily aeronautics R&D facilities – especially many of the materials processing facilities. In addition, several of the working group members were aware of facilities that were not in the inventory; these were also considered.

Because of constraints on time and available information, only government facilities were considered for full evaluation. A general characteristic of many of the facilities in this area is that they are small, integral and essential to the R&D programs at their location. This is particularly true for materials processing facilities, environmental effects facilities, non-destructive evaluation (NDE) facilities, and avionics facilities. There are several large facilities in the thermal vacuum chamber, structures and the structural dynamics areas.

I.D.3 Human and Machine Operations Working Group

Overall, existing human and machine operations R&D facilities are adequate to meet the needs of the baseline space mission requirements model. The working group noted that clarification of roles and missions is necessary to effectively assess and analyze facility utilization. In addition, the different requirements of research and operations need to be carefully considered in effectively evaluating facility needs and capabilities.

In addition, the group concurred in the finding that the current facilities inventory database is inadequate to evaluate the nation's space R&D facility investment and potential for the future, but should be developed and maintained to serve national needs. Also, many of the human and machine operations facilities are used for applications other than space R&D. The working group took this into consideration when evaluating these facilities.

I.D.4 Information Systems and Communications Working Group

Existing information systems and communications R&D facilities were judged adequate to meet the needs of the baseline space mission requirements model. The existing R&D facilities are also either adequate to meet the needs of model excursions or would have a facility development lead time much shorter than the time required for relevant excursions to acquire higher levels of planning reality (thus, allowing time in the future to determine concrete R&D facility requirements and plans).

The working group concurred in the need for on-schedule completion of the *DECADE* nuclear weapons effects test facility at AEDC, because this facility will be the only viable operational alternative to underground testing. The working group also concurred in the planned deactivation of the "Mirror Refurbishment Facility" at the Jet Propulsion Laboratory (JPL). In another area, the group found that at present, there are 40 antenna test facilities in the NFS data base; this suggests that a significant excess capacity may exist. However, study efforts to date have not identified any of the 40 that are not 'needed' to accomplish the role/mission of the owning organization. A formal screening process, under the auspices of the Space Technology Interdependency Group (STIG), is recommended to inhibit future growth of this over capacity.














Other observations include the following:


- Very few Information Systems and Communications facilities, considered individually, are needed to meet the mission model. Most are needed only to fulfill the role/mission of the owning organization.
- Considered in the aggregate, there is a substantial amount of excess capacity in most subcategories of Information Systems and Communications Facilities.
- Reported operations and maintenance costs for those Information Systems and Communications R&D facilities in the database grossly understate the potential savings due to closure where closure is associated with a loss of an organizational role. However, significant savings may be realized only if organizational responsibility for a discipline, as distinct from a product line, is lost.

I.E Actions Needed and Estimated Schedules to Complete

In general, the recommendations of the Space R&D Working Groups are suggested to be implemented in phases over the next several years. Figure 2 summarizes the actions needed, specific facilities and estimates schedules to complete the recommendations. The Task Group recommendations of a broader nature which relate to facilities management, policy, and decision-making are discussed in Section IV.A. These and the specific facilities actions are prioritized in Section IV.B.

FIGURE 2 – NFS SPACE RESEARCH AND DEVELOPMENT FACILITIES PLAN
MATCHED TO MISSION AND REQUIREMENTS MODEL

	YEAR									
	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03
 CONSOLIDATIONS  UPGRADES										
POWER AND PROPULSION • CONSOLIDATIONS • UPGRADES / NEW										
INFO SYSTEMS & COMM. • CONSOLIDATIONS • UPGRADES / NEW										
HUMAN & MACHINE OPS • CONSOLIDATIONS • UPGRADES / NEW										
MATLS, STRUCTURES & F.D. • CONSOLIDATIONS • UPGRADES / NEW					 					

2010 

NOTES:

- | | | |
|--|------------------------------------|---|
| 1. Close JPL mirror refurbishment facility | 5. Deactivate SSC A-2 | 9. New cold optics facility |
| 2. Human-rated test facility at JSC | 6. Complete AEDC DECADE | 10. New E-beam composites R&D facility |
| 3. New microgravity aircraft | 7. Consolidate USAF structures R&D | 11. Nuclear Thermal Propulsion Facilities |
| 4. Consolidate WSTF 300/400 | 8. Deactivate SSC A-1 | 12. Advanced motion effects R&D center |

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Section II

INTRODUCTION**II.A Methodology****II.A.1 Summary**

The purpose of the space R&D facilities study was to determine the capability of national and international space R&D facilities to meet future space R&D requirements and to formulate a coordinated national strategy for world-class space R&D facilities that meet current and projected needs for commercial and government space-related research and development. Figure 3 provides a summary overview of the Space R&D Facility Task Group's methodology. A complete copy of the Space R&D Task Group Terms of Reference (TOR) is provided in Appendix A.

II.A.2 Relationship to Other Elements of the NFS

Beyond general coordination and cooperation (e.g., in overseeing the development of the NFS computerized inventory), the Space R&D Task Group coordinated with the other elements of the NFS in several specific cases. These included:

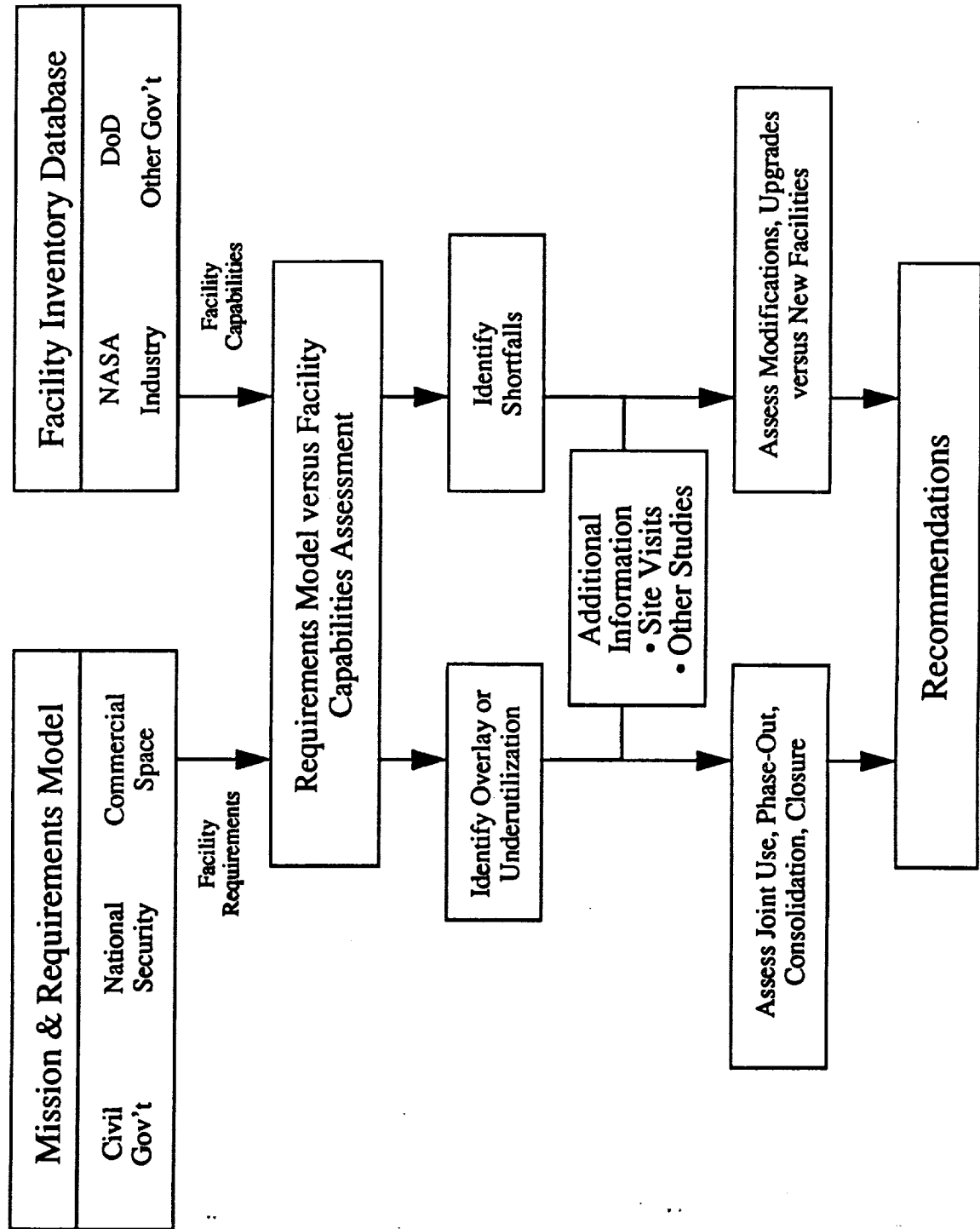
- Common agreement to develop and use a not-inconsistent space mission and requirements model between the Space R&D and Space Operations task groups.
- Conduct of a Space R&D/Operations joint workshop to solicit top-level industry inputs to the study.
- The Space R&D Task Group was assigned responsibility for all spacecraft manufacturing facilities. The group was also assigned responsibility for all propulsion R&D and operational testing requirements and facilities. These analyses were coordinated with the Space Operations Task Group.
- The Aeronautics R&D Task Group was assigned responsibility for analyzing all wind tunnels utilization, including use for Space Operations and Space R&D activities. This group was also assigned responsibility for hypersonics R&D facilities.
- The Space Operations Task Group was assigned responsibility for analyzing all large water tank simulators ('swimming pools'), including use for Space R&D activities.
- The Space R&D and Space Operations task groups agreed to use common working groups in the areas of Strategy and Policy.

II.A.3 Division of work by disciplines

Within the Space R&D Task Group, seven working groups were formed, including four groups chartered to examine facilities in four focused R&D areas: Propulsion and Power; Materials, Structures and Flight Dynamics; Human and Machine Operations; and, Information Systems and Communications.¹ A description of the disciplines covered by each group follows.

¹ The remaining three working groups were assigned responsibility for cross-cutting study functions, including: Systems Engineering and Requirements; Costing; and, Strategies.

FIGURE 3 SPACE R&D FACILITY STUDY METHODOLOGY



II.A.3.1 Power and Propulsion

This working group was responsible for a focused set of technical discipline areas addressing only two major space R&D areas: propulsion and power. Within each of these, the full range of technical disciplines were considered (e.g., cryogenic fluids management, etc.) Specific areas included:

- Power management and distribution
- Chemical energy storage
- Solar power (e.g., solar array, solar dynamics)
- Nuclear power and nuclear thermal propulsion
- Solar and nuclear electric propulsion
- Low- and high- thrust chemical propulsion
- Vehicle thermal management
- Cryogenic tankage, storage and management

The working group divided its efforts into two major sub-categories:

- Power R&D facilities
- Propulsion R&D facilities (where the latter sub-group also considered government-owned propulsion system production facilities)

Within these groups, 'high-impact power facilities' were determined by working group consensus to be those which were greater than \$5 million capital cost; greater than \$200 thousand annual Operations & Maintenance cost; and, either "world class" or "magnet class" facilities. (Where 'facilities' were defined to be the collection of all test stands in a building or larger testing area.) The analysis did not include 'support facilities' (such as water pumping stations or power substations, etc.). High-impact propulsion facilities were determined by working group consensus. (Definitions of these terms are provided in Section V.2.)

II.A.3.2 Material, Structures and Flight Dynamics

This working group was responsible for a very broad range of technical discipline areas. These included:

- Aerodynamics and aerothermodynamics and thermal protection systems (TPS), including aspects that ranged from materials to environmental simulations (e.g., using arc jets)
- Structural concepts, materials and large space structures, including controls-structures interactions (CSI) and disciplines such as non-destructive evaluation (NDE)
- In-space environments and related materials (e.g., coatings)
- Vehicle avionics, guidance navigation and control (including systems level topics such as vehicle health management)

- In-space materials processing, including diverse areas such as electronic and/or photonics materials processing, biological materials processing, as well as all areas associated with accommodations of ground supporting R&D such as microgravity test facilities (e.g., drop towers)

This working group was responsible for integrating program facilities needs in the area of materials and structures, and flight dynamics. The group also evaluated the appropriateness of facilities to meet those needs. Membership include participants from NASA and DoD. Technical areas of responsibility included aerothermal loads, thermal protection systems (TPS), structural concepts and large space structures, in-space environments, vehicle guidance, navigation and control (GN&C), coatings and advanced materials, materials processing, etc. The group divided its efforts into the nine sub-categories that are listed as follows:

- Aero/thermal/structural loads facilities
- Thermal-vacuum chambers
- Materials processing facilities
- Environmental effects facilities
- Structural dynamics, acoustics and vibration test facilities
- Structures/Non-Destructive Evaluation facilities
- Avionics facilities
- Microgravity facilities
- Spacecraft manufacturing/integration facilities

Within these groups, key facilities for analysis were those which involved significant capital costs (current replacement value) and operations costs. Existing facilities were evaluated against the baseline and excursion mission models for possible closures and/or consolidations. If new facilities were needed, modification of existing facilities was examined first before new construction was considered. Types of facilities included arc jets (for TPS R&D), precision structures testing, controls-structures-integration (CSI) testbeds, atomic oxygen and hypervelocity testing, microgravity simulation, and so on.

II.A.3.3 Human and Machine Operations

This working group was responsible for a number of technical discipline areas ranging from almost pure life sciences to applied technology R&D areas. These included:

- The effects of variations of gravity and acceleration on humans and other living systems
- The effects of altitude and atmospheric variations on humans and other living systems
- Life support and extravehicular activity (EVA) systems
- Spatial orientation
- Robotics
- Human-machine interfaces

The Human and Machine Operations Working Group's charter included considering the interface between human operators and machines, as well as machines that simulate environmental

conditions, such as altitude or high acceleration (G), for the purpose of studying the effects of these environments on equipment or procedures. The working group divided the facilities under consideration into eight major sub-categories:

- Hypergravity facilities
- Hypogravity facilities
- Hypo-/Hyperbaric chambers
- Inertial management
- Life support and extravehicular activity (EVA) systems
- Spatial orientation
- Robotics
- Human-machine interfaces

Across these sub-categories, facilities studied were those that were determined to be: greater than \$2 million capital cost; greater than \$200 thousand annual Operations & Maintenance cost; and, either "world class" or "magnet class" facilities.

II.A.3.4 Information Systems and Communications

This working group was responsible for a diverse range of technical discipline areas. These included:

- Radio frequency (RF) and optical communications systems (including microwave and millimeter wave communications components and devices, ground stations, antennas, monolithic microwave integrated circuits; optical communications components and devices, lasers, detectors, and acquisition and tracking systems; and space communications switching and processing systems such as channel coding, modulators and demodulators, and data compression systems).
- Space information processing systems and associated components and devices, (including ground and space data systems, space data storage media, space data processors, and software (generic)).
- Space sensing systems and associated components and devices, (including passive sensing systems, such as sensors and sensor arrays, optical systems and telescopes, sensor coolers and cryogenic support systems, radiometers and radiometer components; and active sensing systems, such as space-based radar and radar components, Light Detection and Ranging (LIDAR) and LIDAR components, synthetic aperture radar systems and components, and monolithic microwave integrated circuits).

The working group divided its efforts into 10 major sub-categories:

- Antenna Test Facilities
- Radiation Tolerance Test Facilities
- Space-unique Micro-fabrication Facilities

- Optical Ranges
- Airborne Instrument and/or Sensor Test Facilities
- Photodetector/Array Characterization and/or Test Facilities
- Frequency/Time Standards Laboratories; Magnetic Labs and Test Sites
- Optical Laboratories and Facilities
- RF/Microwave/Electronics Laboratories
- Communications Link Simulators

(Out of the 184 Information Systems and Communications facilities, 152 could be classified as being in one of the above 10 sub-categories.) In addition to these groupings, facilities that were included in the working group's analyses were those which met one or more of the following criteria: greater than \$5 million capital cost; greater than \$25 thousand annual Operations & Maintenance cost; and, either "world class" and/or "magnet class" facilities. (Where 'facilities' were defined to be whatever the owners had submitted to the data base; in some cases large complexes, and in others, the contents of a modest sized room with hardware and/or instruments arranged on lab benches and/or in racks.)

II.A.4 How the Mission and Requirements Model was Translated into Facility Requirements

The mission and requirements model was used to determine whether or not facilities in the inventory (available and planned changes) could accommodate the baseline and excursions in the model. The model was not used to determine the specific details of how future space programs would be implemented. (This was particularly true for missions in the later years, e.g., after 2003.) Each working group was responsible for developing an approach to applying the model to their specific technical area for facilities analysis. Generally, across the groups the model was used to provide clarification of specific mission requirements and related R&D issues. Mission requirements were used to identify technology R&D needs, which were, in turn, used to estimate R&D facilities requirements. For example, in one of the excursions the model identified a target date for potential development of a new Highly Reusable Vehicle (HRV), allowing consistent analysis of the R&D requirements and potential facility accommodation impacts of such a major system development.

II.A.5 Generalized Description of Analysis Procedures

The Task Group chartered the several working groups and tasked them with responsibility for analyses of Space R&D facilities in specific technical areas. Where overlaps arose, a particular working group was assigned responsibility for all or a specific element of each technical area. The working groups conducted analyses through meetings and teleconferences, including a number of site visits and facilities tours. Each working group then made reports on its findings and preliminary recommendations to the Task Group, which in turn integrated and synthesized those results, and — where necessary — requested additional analysis to strengthen or extend them. The Task Group also conducted regular teleconferences and periodic meetings, including selected site visits, to plan, coordinate, and review results from the several working groups.

II.A.6 Generalized Description of Costing Procedures

Each technology area-focused working group was assigned responsibility for analyzing cost factors for the facilities under its purview. To assist this effort, each group was assigned a cost analyst to provide support. In addition, the Costing Analysis working group provided overall guidelines for use by these groups in analyzing costs (and potential cost-related benefits of proposed recommendations - e.g., closures). These guidelines are summarized below.

- Cost analysis of the buildings/facilities selected for potential consolidation or closure was focused on the five-year period from FY 1994 through FY 1998 for several categories of information (such as facility maintenance).
- For plans in a designated year, planned facility modernization or upgrades were specified (if funded by facility construction appropriation).
- Appropriate annual full time equivalents (FTEs) were provided for (1) maintaining and operating the facility, and (2) for programmatic personnel housed in the facility. If closures or consolidations were recommended, the analysis was to include an assessment of the financial impact for relocating the programmatic FTEs, if required.
- Current replacement value of the facility and its outfitting was identified.
- Facility utilization (as a percentage of total capacity) was to be provided with the goal of identifying excess capacity.

II.B Evaluation Criteria

Each working group tailored its detailed evaluation processes as appropriate for the technical area studied. In addition, overall space R&D working group evaluation criteria included the following:

- Capability of the facility to meet national needs in space R&D. In this case, 'national' encompasses commercial, civilian government, and military sectors, and 'needs' could be derived from planned missions, strategic R&D planning, or from international economic competitiveness considerations.
- Criticality to R&D. Criticality of the facility relative to the conduct of key space research and/or to the development of key space technologies, where 'key' related to enabling or significantly enhancing national missions, strategies, and/or economic competitiveness.
- Uniqueness. The degree to which the facility had no equal elsewhere.
- Facility cost. Measured as life cycle costs minus 'sunk' costs; which included costs described in Section II.A.6 above.
- Criticality to Organization. The criticality of the facility to the capability and mission of its parent institution and its economic competitiveness.
- Feasibility of shared usage of the facility. Includes accessibility to outside organizations, ability to accommodate/protect classified or proprietary commercial

R&D, location and its effect on logistics, work flow, need for co-location of engineering and/or project personnel; and, flexibility, adaptability and versatility.

These criteria were not intended to cover every scenario in exactly the same way -- they were not used as an all-encompassing list to be rigidly applied to every facility under consideration without regard to other issues. Also, equal weighting among these factors for all cases was not implied.

Section III

WORKING GROUP FINDINGS AND RECOMMENDATIONS

All Space R&D facilities were grouped into one of several distinct categories by each working group, including:

Category 1: The working group evaluated the facility and developed a firm recommendation regarding it: consolidate, close, modify, transfer, enhance, or no change. One of two sub-categories was specified:

Category 1A: Recommended changes to the status quo or advocated ongoing changes that are consistent with National Facility Study objectives.

Category 1B: Recommended no change. (Facility is required to support the mission model.)

Category 2: Further study is needed and is merited based on preliminary analysis.

Category 3: No recommendations made at this time due to lack of data, insufficient time to assess and in some instances an initial assessment of no significant cost savings to be realized.

The following section provides the detailed reports from the four technology-focused working groups. (Tables 4 and 5 provide summaries of these data.)

**TABLE 4 - SPACE RESEARCH AND DEVELOPMENT TASK GROUP
FACILITIES BY CATEGORY**

Facilities by Category	NUMBER	PERCENTAGE
Category 1A	23	5
Category 1B	313	63
Category 2	56	11
Category 3	105	21
TOTAL	497	100

**TABLE 5 - SPACE RESEARCH AND DEVELOPMENT TASK GROUP
FACILITY FINDINGS**

Category	TECHNICAL AREA			
	POWER & PROPULSION	HUMAN & MACHINE OPS	MAT'L'S, STRUCTURES & FD	INFORMATION & COMMUNICATIONS
FACILITIES WITH RECOMMENDED CHANGE (Category 1A)	9	1	3	2
FACILITIES WITH NO RECOMMENDED CHANGE (Category 1B)	23	73	53	115
FACILITIES STILL UNDER REVIEW (Category 2)	15	5	29	0
FACILITIES NOT EVALUATED (Category 3)	56	30	20	27
TOTAL FACILITIES	103	109	105	144

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POWER AND PROPULSION WORKING GROUP

FACILITY FINDINGS

SPACE R&D TASK GROUP

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III-5

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Power and Propulsion Working Group

Responsibility: Technical Areas of Responsibility

Power Management & Distribution (PMAD), Chemical Energy Storage, Solar, Nuclear & Thermionic Power, Energy Conversion, Chemical Electric, Solar & Nuclear Propulsion, Vehicle Thermal Management; Cryogen Tankage & Storage; Propellants; Feed Systems; and Advanced Concepts for Power and Propulsion

Responsibility: types of Facilities

Major and/or Strategically Important Facilities, ie, Thermal Vacuum Chambers; Power System Test Facilities; Chemical, Electric & Solar Propulsion Test Stands; Nuclear Reactors to support Propulsion & Power; Cryogenic Storage & Feed System Stands; Propellant Mixing & Test Installations; Integrated Vehicle Systems Stands

General Comments

This working group will be responsible for integrating program facility needs in the area of power and propulsion related R&D and evaluating the appropriate facilities to meet those needs.

This working group will be responsible for identifying common characteristics & capabilities, and for identifying strategic enhancements and excess capabilities in R&D facilities. The working group will coordinate between other technical working groups and make recommendations to the R&S WG.

POWER AND PROPULSION WORKING GROUP CATEGORY 1A RECOMMENDATIONS

POWER AND PROPULSION CATEGORY 1A FACILITY INDEX

We have reviewed the Space R&D facilities available for use by National programs. Most of our attention was placed on Government facilities. Four areas where action should be taken are recommended:

- CONSOLIDATE WSTF 300/400 PROPULSION AREAS (NASA)
- CONSOLIDATE HIGH PRESSURE ROCKET ENGINE COMPONENT (TURBOPUMP) TEST CAPABILITY (DoD/NASA)
- DOWNMODE A-2 AND A-1 TEST STANDS AT STENNIS SPACE CENTER (DoD/NASA)
- NEW/ UPGRADED NUCLEAR THERMAL PROPULSION AND SPECIALIZED SUPPORT TEST FACILITIES (DoD/NASA/DoE)

POWER AND PROPULSION CATEGORY 1A FACILITY INDEX

FACILITY	LOCATION
300 TEST AREA	NASA WSTF
400 TEST AREA	NASA WSTF
TEST STAND 116	NASA MSFC
CTF	NASA SSC
2-A	DOD PL/ED
E-8	P&W WEST PALM BEACH
TEST POSITION A-2	NASA SSC
TEST POSITION A-1	NASA SSC
NUCLEAR THERMAL PROPULSION	TBD

CONSOLIDATE WSTF 300/400 PROPULSION AREAS (NASA)

The WSTF 300 Area includes 2 altitude and 2 ambient test stands; hypergolic and monopropellant storage, distribution, and disposal systems; a blockhouse, modern data acquisition system, and various other support systems required for a functional test area. Several important attributes of WSTF, including the 300 Area, are the existing environmental permits and on-going environmental compliance programs, and the extensive buffer zone that provides isolation from public encroachment.

The primary program supported at WSTF Shuttle. The Shuttle Forward Reaction Control Subsystem (FRCS) and Aft Reaction Control Subsystem (ARCS) were development tested and qualified in the WSTF 300 Area. The Shuttle Fleet Leader program continues to subject these test articles to mission duty and turn around simulations so that failures or anomalies associated with cycle life or exposure time may be exposed on the ground test articles rather than on the flight systems. In addition WSTF continues to develop streamlined processes which reduce KSC turnaround costs. Flight and ground processing anomalies are also investigated and corrections verified prior to implementation on the flight vehicles. The test articles are also being used to develop and qualify new flight components and improved GSE.

The Space Station propulsion module development tests at Test Stand 302 have recently been terminated because of the Alpha redesign and use of Russian hardware. Based on reduced Shuttle project funding, the need to reduce institutional funds within NASA, and the termination of the Space Station testing, it was recommended to downmode the 300 Area and FRCS, and to relocate the Aft reaction Control System test article to Test Stand 402. This accomplishes the intent of reducing institution funds however based on the mission model and continued Shuttle support, the downmoding may be only temporary. The same committee also identified WSTF as "World Class" in the area of hypergolic propulsion system, components, and materials testing.

The mission model includes Cassini program and WSTF is currently discussing testing required for the Cassini main engine assembly with JPL and Martin Marietta (Prime). The Mars Environmental Survey (MESUR) propulsion system may also be tested in the 300 Area to support the pathfinder and subsequent missions with launches starting in 1996. Small propulsion systems contained in the model require the continued use of hypergolic propellants. The emerging technologies required in small propulsion systems for future missions include high pressure systems and higher performance propellants, both of which are planned to be tested at the WSTF propulsion Areas. It is important to maintain the 300 Area for future small propulsion system development and qualification capability.

CONSOLIDATE WSTF 300/400 PROPULSION AREAS (NASA)

DESCRIPTION: Current Shuttle propulsion testing at WSTF is conducted in five (5) test stands located in two (2) separate test areas. This includes anomaly and upgrade testing of single engines at TS-405 & TS 401 and sea level tests of the Orbital Maneuvering System at TS-403, the Forward Reaction Control System at TS-3 and Aft Reaction Control System at TS-301. It was recommended by a previous NASA Hdqts appointed review team to downmode the 300 Area, including the Shuttle Forward test article located at TS-328, and to move the Aft test article to the 400 area for continued testing. The changes, to be funded with FY94 and FY95 Shuttle programmatic funds already budgeted to WSTF, requires programmatic approval. The 300 Area and Test Stand 328 will be capable of reactivation to support FRCS system level tests or other requirements as given by the Requirements Model.

PAYOFF POTENTIAL:

- \$1M/year after relocation

COST SUMMARY:

Implementation Costs: \$1.5M
O & M Costs: TBD
Anticipated Net Savings: \$1M/year

PROS

- Lower institutional maintenance cost by downmoding one propulsion test area
- Lower programmatic costs by reducing test quantity

CONS

- Minimize fleet lead testing for approximately 1 year
- Slower response time for Forward Reaction System anomaly tests

STEPS TO MAKE IT HAPPEN:

- Receive formal direction
- Implement (requires approximately one (1) year)

TASK GROUP RECOMMENDATION:

- Concur with shuttle test consolidation/downmode 300 Area plan
- Provide funding for maintenance/upgrades consistent with the Requirements Model

DATE: 1/13/94 REV: 3/19/94

CATEGORY 1A





CONSOLIDATE HIGH PRESSURE ROCKET ENGINE COMPONENT (TURBOPUMP) TEST CAPABILITY (DoD/NASA)

National ground test capability for the high pressure components of large rocket engines has been developed over the past 35 years to meet the needs of individual agencies, programs or industries. As a result, the National inventory today counts as many as eight (8) high pressure ground test facilities, some of which are incomplete and some of which are so specifically designed/constructed as to be able to test only one (1) component particular to a specific engine system. The current baseline requirements model indicates that National (ie, DoD & NASA) technology programs, as well as excursion options requiring a new engine development support the continuing need for ground test capability in this area.

Of the eight (8) facilities, three (3) are at Government locations, and are available for use by Government and/or industry "customers" with theoretically few restrictions. The remaining five (5) facilities are at Industry locations, often designed/constructed/outfitted with a mix of Government/Industry funds, over a period of sometimes many years. Historically, there has been little cross-utilization of Industry facilities by other Industry elements, except for joint ventures or like arrangements. Often times, an Industrial element is unwilling to consider the ground test of a particular component at a competitor's test facility for fear of the loss of a competitive advantage.

During the mid- to late 1980's, at the beginning of the Advanced Launch System (ALS) Program, the Government Team, comprised of both DoD/USAF & NASA, initiated a program to enhance the capability of the National test facility inventory at Government locations. In addition to the considerations in the previous paragraph, another reason for the implementation of this plan was to make the capital investments available during a time of National fiscal constraint at Government locations, available and open to all customers, but also available for future programs, ie after the ALS Program.

NASA MSFC TS-116 is currently capable of testing certain high pressure combustion devices and with minor enhancement, would be capable of testing much larger combustion devices (ie, 750K to 1.5 million lb. thrust). With further enhancement, a useful capability for testing turbopumps could be achieved. DoD PL-Edwards TS 2-A, originally designed to perform combustion device testing for the ALS Focused Technology/Advanced Development Program, is approximately 66% complete for this purpose and is currently being used for moderate pressure turbopump testing. With additional investment, TS 2-A could be completed for the original designed purpose of high pressure (HP) combustion device testing, and with further enhancement/investment could be equipped for HP turbopump testing. NASA SSC CTF, was originally designed to support focused technology/advanced development/development/certification/acceptance testing of all ALS components, both turbopump and combustion devices. The CTF is currently about 60% complete to support focused technology and advanced development.

These HP component test facilities should be National assets. New investment or enhancement should be limited to Government locations unless there are compelling mitigating circumstances.

DATE: 1/19/94

CATEGORY 1A

CONSOLIDATE HIGH PRESSURE COMPONENT (TURBOPUMP) TEST CAPABILITY (DOD/NASA)

DESCRIPTION: The Nation currently has as many as eight (8), high pressure component test stands capable of testing large components for rocket engines. Notable among these are three (3) facilities at Government locations and one (1) facility at an industry location. The three (3) Government locations are as follows: Test Stand 116 (TS116) at NASA MSFC, Test Stand 2A at USAF Phillips Lab-Edwards and the Component Test Facility (CTF) at NASA SSC. None are fully completed for high pressure component testing. The one industry location is Test Stand E-8 at Pratt & Whitney, West Palm Beach, FL. This stand has been used recently for high pressure component testing. The current requirements include DOD and NASA technology programs and a requirement for new large engine options to support the Access to Space needs. This latter requirement is currently shown as an excursion.

PAYOFF POTENTIAL:

- Cost avoidance by not completing/maintaining facilities that are not be required.

COST SUMMARY:

Implementation Costs: TBD
O & M Costs: TBD
Anticipated Net Savings: TBD

PROS

- Provides 2 World Class Facilities
- Consolidates activities of 8 plus facilities into 2 or 3
- Avoids cost to complete redundant facilities

CONS

- Loss of on-site capability at some industry locations

STEPS TO MAKE IF HAPPEN:

- Complete Category 2 Study to select best sites (of the 4 options)
- Withhold government funds planned for the redundant facilities. Identify government owned equipment and the preferred disposition

TASK GROUP RECOMMENDATION:

- Assure availability of 2 World Class facilities ASAP--Potential need for 3rd facility later
- Stop providing government support to the redundant facilities
- Conduct a Category 2 Study to select the required facilities

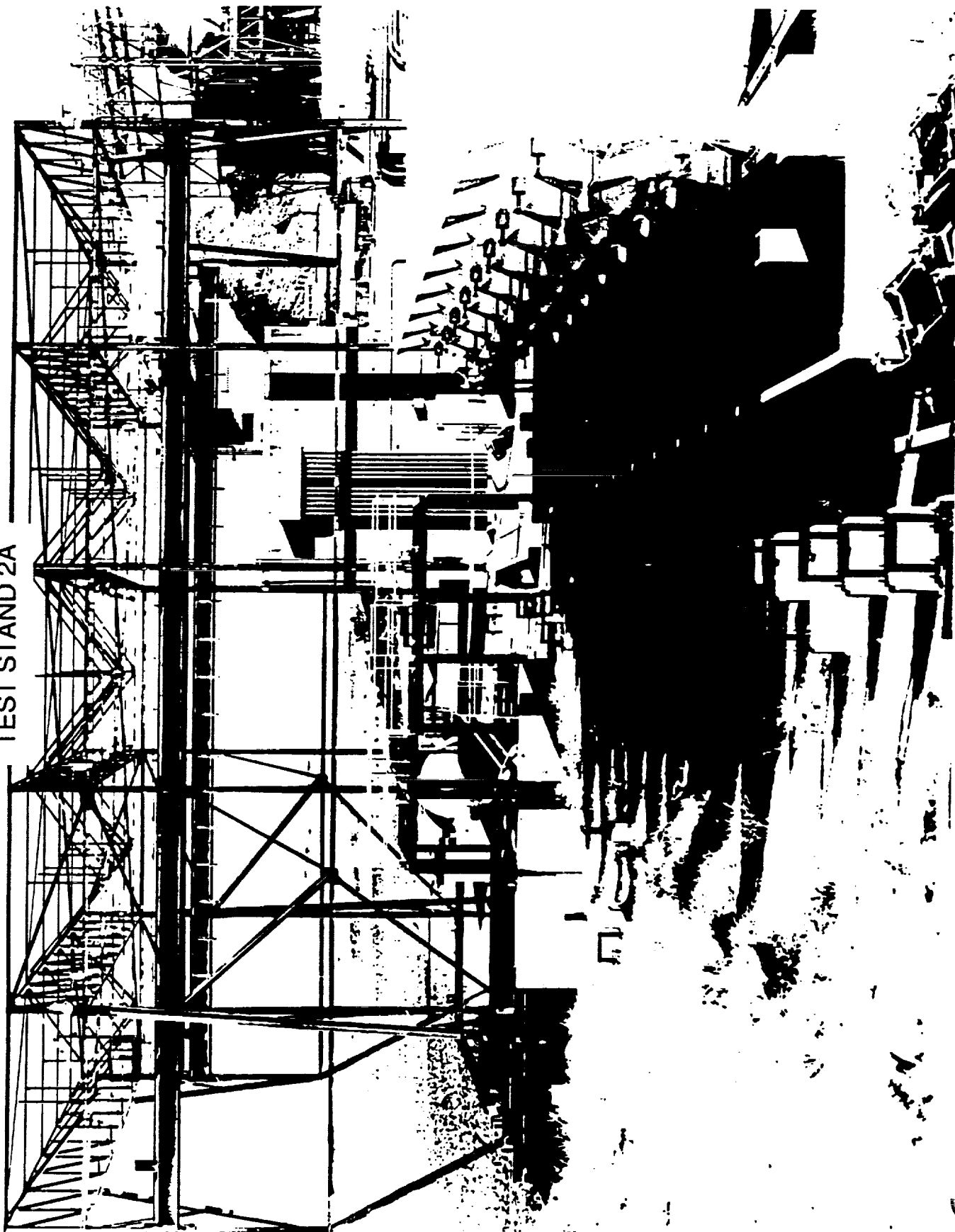
DATE: 1/19/94

REV: 3/23/94

CATEGORY 1A

PHILLIPS LAB/EA FB

TEST STAND 2A



TEST STAND A2

TEST STAND B1/B2

TEST STAND A1



STENNIS SPACE CENTER
COMPONENT TEST FACILITY

DOWNMODE A-2 AND A-1 TEST STANDS AT STENNIS SPACE CENTER (DoD/NASA)

Space Shuttle Main Engine (SSME) ground testing began at Stennis Space Center (SSC) in 1975. By 1985, SSME Project test requirements dictated use of three (3) test stands--two (2) at SSC (A-1 and A-2) and one (1) at Santa Susanna Field Laboratory (SSFL) in California (Rocketdyne A-3). In order to incorporate efficiencies and save costs, all SSME testing was consolidated at SSC, by outfitting the B-1 Test Stand at SSC and deactivating the Rocketdyne A-3 Test Stand at SSFL, CA. Coincident with this decision, the SSME test rate greatly expanded at SSC in the aftermath of the CHALLENGER accident. Since the spring of 1987, three (3) SSME test stands have been in operation at SSC in support of the SSME Project.

Concurrently, the Advanced Engine Test Facility, originally the Technology Test Bed (TTB), at NASA MSFC, was activated to provide NASA with a test bed for advanced large rocket engine testing. Advanced development work has been performed at this test stand using an SSME. Development and certification testing of the SSME is not accomplished at the AETF.

Recently, the SSME test rate requirement for out year planning has dramatically reduced. SSME Project planning includes a decision to stop SSME testing on the SSC A-2 Test Stand in mid-CY95. Further curtailment of SSME testing is scheduled when SSME testing on the SSC A-1 Test Stand ceases at the end of FY97. As the Shuttle Program exists today, SSME Project test rate projects support this scenario. If the SSME test rate requirement changes, the recommendations may change.

DOWNMODE A-2 AND A-1 TEST STANDS AT STENNIS SPACE CENTER (DOD/NASA)

DESCRIPTION: The Nation currently uses three (3) large single-engine test stand positions at the NASA Stennis Space Center (SSC) to test the Space Shuttle Main Engine (SSME). A fourth test stand, the Advanced Engine Test Facility (AETF) at the NASA Marshall Space Flight Center (MSFC) uses an SSME as the basis for a Technology Test Bed (TTB) to test advanced rocket engine technologies. Currently the SSME test rate does not require use of three (3) test stands at SSC after mid-CY95.

PAYOFF POTENTIAL:

- Downmode of the Test Stand A-2 will save the SSME Project (ie, Space Shuttle Program ~\$35M/year
- Downmode of the Test Stand A-1 will save the SSME Project \$TBD M/year

COST SUMMARY:

Implementation Costs:

O & M Costs: \$100K each/ year (continuing after downmoding)

Anticipated Net Savings: \$35M/year starting mid-CY95

\$ TBD M/year starting late FY97

PROS

- Major savings

CONS

- Restoration of the back-up altitude simulation test capability, if the A-2 has been downmoded (ie, with maintenance) will take 6-9 months

STEPS TO MAKE IT HAPPEN:

- Current SSME Project Planning schedules the downmoding of SSC Test Stand A-2 in mid-CY95
- Current SSME Project Planning schedules the downmoding of SSC Test Stand A-1 in late FY97

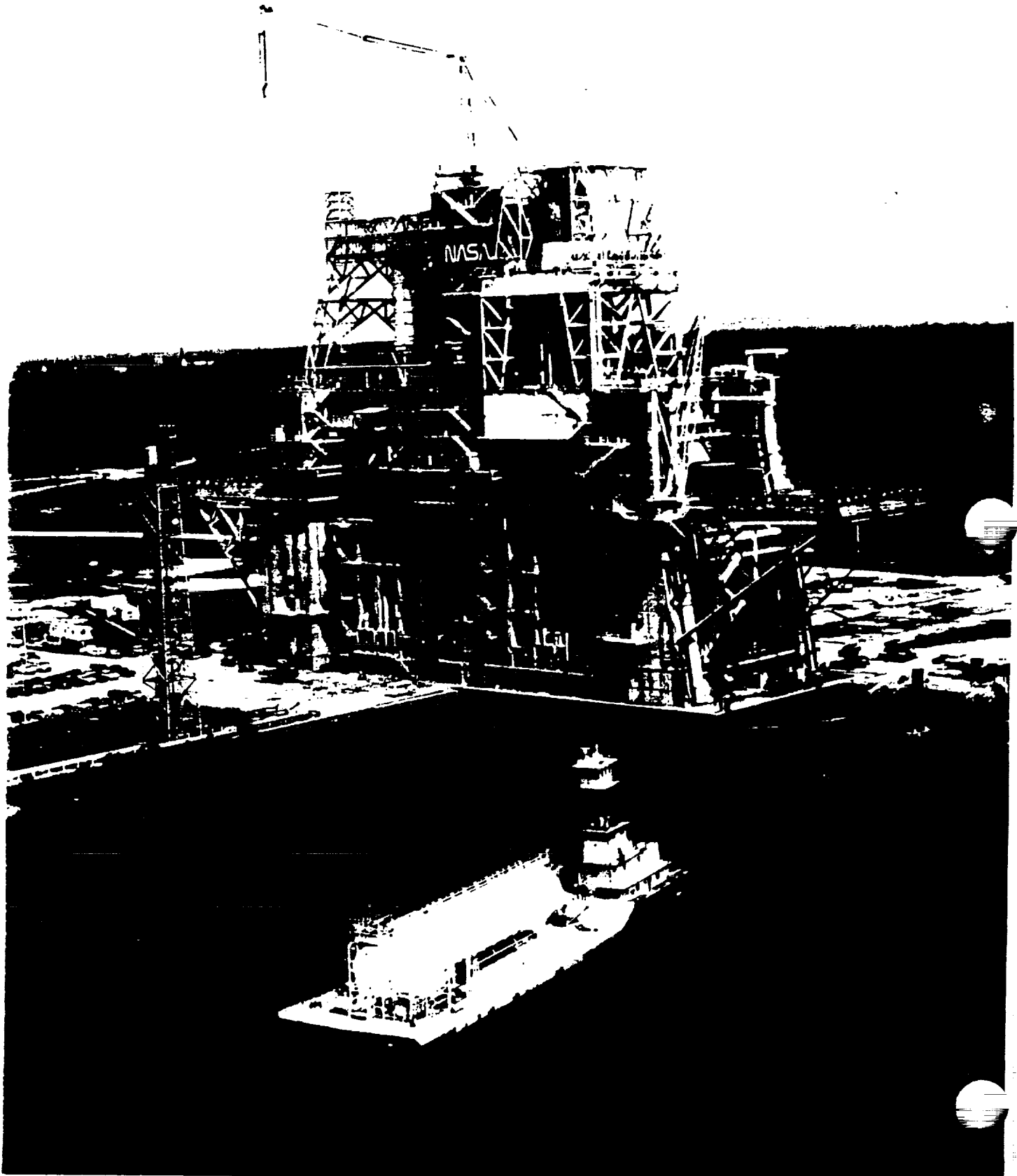
TASK GROUP RECOMMENDATION:

- Concur with the SSME Project Plans to downmode SSC Test Stands A-2 in mid-CY95 and A-1 in late FY97
- Provide funding for residual minimum maintenance to preserve the National investment in SSC Test Stands A-2 and A-1 (\$100K each /year after downmode)
- The A-2 diffuser should be maintained during this downmode as a spare/replacement in the event of a catastrophic failure of the Test Stand B-1 diffuser (est. cost: \$25K/year)

DATE: 1/12/94 **REV:** 3/21/94

CATEGORY 1A

STENNIS SPACE CENTER
TEST STAND B1/B2



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NEW/ UPGRADED NUCLEAR THERMAL PROPULSION AND SPECIALIZED SUPPORT TEST FACILITIES (DEPENDS ON "EXPLORATION" EXCURSION)

In 1990 and 1991 a Space Nuclear Propulsion Test Facility Panel with representatives for NASA, DoE, DoD and Private Industry observers documented a study of the nations facilities, both existing and those required to support a National Nuclear Thermal Propulsion Program. These studies and recommendations have been published as NASA Technical Memorandums 105708 and 105710. The facility categories considered include: fuel fabrication, unirradiated materials, hot hydrogen, irradiation, low-power critical fuel element loops, prototype fuel element reactor, engine ground test, remote inspection, component, control, training and simulator, engine integration, flight and system -level safety. The facilities are cataloged by location and use and an investment strategy for upgrading and building new facilities is also provided.

This unfunded study concluded that a full up National Nuclear Thermal Propulsion Program would require major upgrades to several existing facilities, but that only one new site needs to be developed from the ground up. However, this positive finding needs to be tempered with the realization that a significant amount of program funding resources will still be required for existing facility modifications, element/reactor/engine test facility development, and test operations. It was assumed that from the completion for the new facility to the completion of the engine ground tests would be approximately ten (10) years. Therefore, there is a considerable lead time required to facilitate in support of a nuclear thermal propulsion program and that significant funding will be required in those early years.

If a decision is made to develop nuclear thermal propulsion for an exploration excursion, it will be extremely important to make reactivation, upgrade and new construction decisions against a national agenda. Without this agenda there should not be any expenditure on facilities needed exclusively to support nuclear thermal propulsion. The risk to the national facility inventory is that without program justification there will be no maintenance funding with the resulting further deterioration of important facilities.

TASK GROUP RECOMMENDATION:

- Once a decision is made, update recent study and use as investment strategy
- Significant investment in new facilities will be required
- Make no capital investments for facilities required exclusively to support nuclear thermal propulsion without a National decision.

DATE: 1/18/94 REV: 3/19/94

CATEGORY 1A (Dependent on Excursion)

NEW/ UPGRADE NUCLEAR THERMAL PROPULSION AND SPECIALIZED SUPPORT TEST FACILITIES

(DOD/NASA/DOE)

(DEPENDS ON "EXPLORATION" EXCURSION)

DESCRIPTION: In 1990 and 1991 a Space Nuclear Propulsion Test Facility Panel with representatives from NASA, DoE, DoD and private Private Industry observers documented a study of the nations facilities, both existing and required to support a Nation Nuclear Thermal Propulsion Program. These Studies and recommendations have been published as NASA TM's 105708 and 105710. The facilities are cataloged by location and use and an investment strategy for upgrading and building new facilities is provided. It was assumed that from the completion of the first new facility to the completion of the engine ground tests would be approximately ten (10) years.

PAYOFF POTENTIAL:

- Make reactivation, upgrade and new construction decisions against a national agenda and in the most cost effective manner

COST SUMMARY:

Implementation Costs: TBD

O & M Costs: TBD

Anticipated Net Savings: TBD

PROS

- Optimize on a National agenda
- No expenditure without a national program

CONS

- No current programs to justify maintenance/upgrade

STEPS TO MAKE IT HAPPEN:

- Once a decision to explore (excursion) is made, update recent study and use as investment strategy

TASK GROUP RECOMMENDATION:

- Significant investment in new facilities will be required
- Make no capital investments for facilities required exclusively to support nuclear thermal propulsion without a National decision

DATE: 1/12/94 **REV:** 3/19/94

CATEGORY 1A*

* Dependent on excursion

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POWER AND PROPULSION WORKING GROUP
CATEGORY 1B RECOMMENDATIONS

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POWER AND PROPULSION CATEGORY 1B FACILITY INDEX

We have identified and reviewed power and propulsion facilities associated with Space Research and Development utilizing The National Facilities Study Facilities Inventory Database coordinated by GRC. Our analysis of the mission model requirements and our review of the facilities indicate that the current and planned status for the facilities on this list are appropriate.

POWER AND PROPULSION CATEGORY 1B FACILITY INDEX

PROPULSION FACILITY	LOCATION
ROCKET ENGINE TEST FACILITY	NASA LeRC
SPACECRAFT PROPULSION TEST FACILITY	NASA LeRC
ADVANCED ENGINE TEST FACILITY	NASA MSFC
SOLID PROPULSION TEST FACILITY	NASA MSFC
TEST STAND H-1	NASA SSC
TEST POSITION B-2 (B TEST STAND)	NASA SSC
TEST STAND B-1	NASA SSC
MK-1	DOD AEDC
J-3	DOD AEDC
J-4	DOD AEDC
J-5	DOD AEDC
J-6	DOD AEDC
1-B,D,E	DOD PL/ED
1-56	DOD PL/ED
1-C	DOD PL/ED
NHTF	DOD PL/ED
1-42A,B,D,E	DOD PL/ED
POWER FACILITY	LOCATION
ELECTRIC POWER LAB	NASA LeRC
DYNAMITRON RADIATION EFFECTS LAB	NASA JPL
25 FT. SPACE SIMULATOR	NASA JPL
THERMIONIC SYSTEM EVALUATION TEST LAB	DOD PL/A
BATTERY TEST FACILITY	DOD NSEC/CRANE
SOLAR ARRAY FACILITY	LOCKHEED

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POWER AND PROPULSION WORKING GROUP CATEGORY 2 RECOMMENDATIONS

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POWER AND PROPULSION CATEGORY 2 FACILITY INDEX

The Power and Propulsion Working Group has reviewed facilities required for High Pressure Component (Turbopump) testing, Large Hydrocarbon Tripropellant testing, and Large Hybrid testing and have come to the conclusion that further study is necessary to determine what specific facilities are required to support future test requirements. We have discussed the feasibility of using government facilities or using a mix of government and industry facilities. We have not been able to discuss, in the depth necessary to make a final recommendation, such issues as cost to complete, cost to operate, availability, assured proprietary protection, and fair and reasonable user fees. A complete list of contractor facilities was not available from the database in time to be considered in this study.

POWER AND PROPULSION CATEGORY 2 FACILITY INDEX

SELECT NATIONAL HIGH PRESSURE	
COMPONENT (TURBOPUMP) TEST FACILITY	
TS116	NASA MSFC
2A	DOD PL/ED
CTF	NASA SSC
E-8	P&W
LARGE HYDROCARBON TRIPROPELLANT	
e.g.	
F-1	NASA MSFC
1-A	DOD PL/ED
TEST POSITION B-1 (B TEST STAND)	NASA SSC
J-4	DOD AEDC
LARGE HYBRID	
e.g.	
TF-500	NASA MSFC
TEST POSITION B-2 (B TEST STAND)	NASA SSC
TEST STAND H-1	NASA SSC
1-56	DOD PL/ED
1-C	DOD PL/ED
J-5	DOD AEDC
J-6	DOD AEDC

SELECT NATIONAL HIGH PRESSURE COMPONENT (TURBOPUMP) TEST FACILITIES (DOD/NASA)

There are currently several government and contractor large high pressure component test facilities capable of testing large components for rocket engines. We have discussed the feasibility of using government facilities to meet this need or using a mix of government and industry facilities. We have not been able to discuss, in the depth necessary to make a final recommendation, such issues as cost to complete, cost to operate, availability, assured proprietary protection, and fair reasonable user fees. A complete list of contractor facilities was not available from the database in time to be considered in this study. More data is required on the projects to be supported for future excursions into improve/re-engineered space launch vehicles to determine the most cost effective facilities to use. The issue of facility location vs technologist's location must also be considered.

To make a final decision on the number of these facilities required and their location, several steps must be taken. The NASA, DOD, and industry must commit to making the selections from a National perspective. All issues currently unresolved must be studied and final decisions made. The Liquid Propulsion Industry Advisory Group must determine the terms and conditions necessary to make a contractor facility, such as the E-8 stand at P&W fully acceptable to other industry users. NASA and P&W must determine ownership of the various components of the E-8 stand. DOD and NASA must do a cost study to determine the advisability of cannibalizing or purchasing new components to complete the candidate facilities.

It was agreed at the last meeting the Power and Propulsion Working Group that R&D level projects at existing government stands should continue, but any buildup for a specific system engine development should be deferred until the results of this Category 2 study are available.

SELECT NATIONAL HIGH PRESSURE COMPONENT (TURBOPUMP) TEST FACILITIES (DOD/NASA)

DESCRIPTION: The Nation currently has as many as eight (8), high pressure component test stands capable of testing large components for rocket engines. Some of the key factors in making the best selection for the Nation are costs to complete, cost to operate, availability, nature of existing test operations, assured propriety and fair and reasonable use fees.

PAYOFF POTENTIAL:

- Meet National Requirements at the least cost

COST SUMMARY: Implementation Costs: TBD

O & M Costs: TBD

Anticipated Net Savings: TBD

PROS

- Avoids cost to complete redundant facilities
- Provides World Class Facilities

CONS

- Loss of ready access & control at industry sites

STEPS TO MAKE IT HAPPEN:

- The NASA, DOD and Industry commit to making the selections from a National perspective
- Complete the elements of the study
- Make the selections--document agreements--implement

TASK GROUP RECOMMENDATION: Under the auspices of the AACB:

- Task an ad hoc technical industry/government group to determine the terms and conditions necessary to make industry own/sited facilities equally accessible to all industry users
- Task the hosts of the primary candidate facilities to determine the costs to bring the facilities up to their original planned capability
- Task DOD & NASA to do a cost analysis based on the requirements of 1, 2 or 3 facilities, & determine the advisability of cannibalizing Vs purchasing new components to complete the candidate facilities
- Using the above information, select two facilities for completion ASAP

NASA OSF & DOD SAF/AQ fully fund the completion of the selected facilities.

DATE: 1/12/94

REV: 3/24/94

CATEGORY 2

REACTIVATE/UPGRADE LARGE LIQUID OXYGEN/HYDROCARBON/TRIPROPELLANT TEST FACILITIES (DOD/NASA)

There are currently several contractor and government large liquid test stands where large liquid oxygen/hydrocarbon/tripropellant testing could be performed. We have discussed the feasibility of using the government facilities for this type of testing, but not in the depth required to make a concrete recommendation for the most favorable site at this time. Potential contractor facilities were not entered into the database in time to be considered in this study. The issue reactivating/upgrading a candidate test stand(s) has been deferred for consideration as more data becomes available and the requirements for facilities required for static testing related to future excursion into improved/re-engined space launch vehicles for space lift missions more clear.

To further address the selection of sites for large liquid oxygen/hydrocarbon/tripropellant test stands for future space launch vehicle needs, the Power and Propulsion Working Group recommends that the subject facilities be maintained in their current condition until an opportunity for further study determine the best mixture of test stands to perform static testing for any postulated excursions mission. This group sees no advantages for consolidations or closures at this time. For the best possible results, site selection should be tied to as specific a mission as can be foreseen.

To make this recommendation happen the ASEB and overview group need to concur with this recommendation; a study group needs to be commissioned, preferably with equal representation from DOD and NASA.

REACTIVATE/UPGRADE LARGE OXYGEN/HYDROCARBON/ TRIPROPELLANT ROCKET ENGINE TEST FACILITIES (DOD/NASA)

DESCRIPTION: There are currently three (3) primary government sites where large liquid oxygen/hydrocarbon/tripropellant rocket engine sea level testing could be performed, each requiring only minor refurbishment. The three (3) facilities are the 1-A test stand at the Air Force's Phillips Laboratory, Edwards AFB, CA; the F-1 test stand at NASA's Marshall Space Flight Center (MSFC), Huntsville, AL; and the B-1 test stand at NASA's Stennis Space Center, MS. The J-4 test stand and DoD's Arnold Engineering Development Center, Arnold AFB, TN could be used if altitude testing is required. One or more of these facilities are required for static testing related to future excursions into improved/re-engined space launch vehicles for improved access to space.

PAYOFF POTENTIAL:

- The reactivation and upgrading of an existing, readily available facility is the least expensive way to provide a national capability for large liquid oxygen/hydrocarbon/tripropellant testing.

COST SUMMARY: Implementation Costs: TBD
 O & M Costs: TBD
 Anticipated Net Savings: TBD

PROS

- Enables near term solution for restoring U.S. competitiveness in the world space launch market
- Focuses facility investments, operations and maintenance costs

CONS

- Facility investment is somewhat speculative until the completion the the Access To Space studies

STEPS TO MAKE IT HAPPEN:

- The NASA, DOD and Industry commit to making the selections from a National perspective

TASK GROUP RECOMMENDATION:

- Complete the study in parallel with the Access To Space studies--Consider need for ambient and altitude tests and the appropriate mix of facilities to meet the test needs--Tie reactivation/upgrade to specific programs and related funding.
- Make the selections--document agreements--implement

DATE: 1/12/94 **REV:** 3/20/94

CATEGORY 2

REACTIVATE/UPGRADE HYBRID ROCKET MOTOR TEST FACILITIES (DOD/NASA)

There are currently a number of government and contractor test stands where hybrid rocket motor testing could be performed. We have discussed the feasibility of using a government facility or mix of government facilities for this type of testing, but not in the depth required to make a concrete recommendation for the most favorable site(s) at this time. Potential contractor facilities were not entered into the database in time to be considered in this study. The issue of reactivating/upgrading a candidate test stand(s) has been deferred for consideration as more data becomes available and the requirements for facilities required for static testing related to future excursions into improved/re-engined space launch vehicles/low cost access to space becomes more clear.

To further address the selection of sites for hybrid rocket motor test stands for future space launch vehicles/low cost access to space needs, the Power and Propulsion Working Group recommends that the subject facilities be maintained in their current condition until an opportunity for further study determines the best mixture of test stands to perform static testing for any postulated excursion mission or government-aided commercial space launch development activity. This group sees no advantages for consolidations or closures at this time. For the best possible results, site selection should be tied to as specific a mission as can be foreseen.

To make this recommendation happen the ASEB and overview group need to concur with this recommendation, a study group needs to be commissioned, preferably with equal representation from DOD and NASA.

REACTIVATE/UPGRADE HYBRID ROCKET MOTOR TEST FACILITIES (DOD/NASA)

Space R&D Task Group

Final Report

DESCRIPTION: There are currently a number of sites (for example, Test Stands 1-56 and 1-C at Phillips Laboratory, Edwards AFB, TF-500 at NASA Marshall Space Flight Center, Test Stands B-2 and H-1 at NASA Stennis Space Flight Center) where large hybrid rocket motor testing under ambient (sea level) conditions is either already being performed or could be performed. In addition, there are several other government and industry sites (for example, Test Stands J-5 and J-6 at DoD Arnold Engineering Center, Arnold AFB, TN) which could be variously modified to accept hybrid rocket test articles, both for ambient testing of first stage motors as well as altitude testing for upper stages. A facility or possibly multiple facilities are required to test hybrid rocket motors for current and planned programs.

PAYOFF POTENTIAL:

- The reactivation and upgrading of existing facilities is the least expensive way to provide a national capability for large hybrid motor testing.

COST SUMMARY:

Implementation Costs: TBD
O & M Costs: TBD
Anticipated Net Savings: TBD

PROS

- Modification of facilities is a cost effective way to meet hybrid motor test requirements
- Focuses facility investments, operations and maintenance costs

CONS

- Facility investment is somewhat speculative until the completion the the Access To Space studies

STEPS TO MAKE IT HAPPEN:

- The NASA, DOD and Industry commit to making the selections from a National perspective

TASK GROUP RECOMMENDATION:

- Complete the study in parallel with the Access To Space studies--Consider need for ambient and altitude tests and the appropriate mix of facilities to meet the test needs--Tie reactivation/upgrade to specific programs and related funding.
- Make the selections--document agreements--implement

DATE: 1/12/94 **REV:** 3/20/94

CATEGORY 2

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POWER AND PROPULSION WORKING GROUP CATEGORY 3 RECOMMENDATIONS

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POWER AND PROPULSION FACILITIES

An initial review of the lists of facilities for both Propulsion and Power was performed to screen out facilities that would have a low potential for savings. By using the evaluation criteria listed on the Propulsion Methodology and Power Methodology charts the 3A list was obtained. This involved eliminating support facilities, combining test stands, applying dollar thresholds for capital and O & M costs, and using the group's combined experience to determine whether these were world class or magnet class facilities.

**POWER AND PROPULSION
CATEGORY 3A FACILITY INDEX**

PROPULSION FACILITY	LOCATION
PROPULSION TEST FACILITY 353	NASA JSC
ELEC. PROP. RESEARCH BLDG. 16	NASA LeRC
ROCKET LAB. BLDG. 35	NASA LeRC
POWER FACILITY	LOCATION
ASTRONICS COMPLEX - AUTO. LRG POWER SYS. LAB	NASA MSFC

POWER AND PROPULSION WORKING GROUP CATEGORY 3B FACILITIES

In general, the Power & Propulsion Working Group found very few facilities in the Data Base that we could not place in the other categories. The few remaining in Category 3B are not because we had no knowledge of the facility but that we had insufficient time to search the mission model to find requirements that relate to them. In other cases the facilities were laboratories that are needed to support the technologies and research of the parent organization. It is recommended that the facilities in Category 3B be analyzed by this or a similar group when more data is available relative to how laboratory type facilities would be used to support the systems required by the mission model.

POWER AND PROPULSION CATEGORY 3B FACILITY INDEX

PROPULSION FACILITY	LOCATION
K-SITE	NASA LeRC
BRAVO TEST AREA SSFL AREA 11	NASA MSFC
COCA TEST AREA SSFL	NASA MSFC
COLD FLOW PROPULSION TEST COMPLEX	NASA MSFC
TEST FACILITY 500	NASA NSFC
CRYO. TEST. FAC.	NASA MSFC
ENG. DYN. FLUID FLOW FAC.	NASA MSFC
HARDWARE SIM. LAB. 4436	NASA MSFC
PROP. SYS. COMP. ALT. AND THERMVAC TEST FAC.	NASA MSFC
PROPELLANT LOAD FAC. SSFL	NASA MSFC
PROPULSION TECH. TEST FAC.	NASA MSFC
PROPULSION TEST FACILITY 4696	NASA MSFC
QUAL. MOTOR FACILITY	NASA MSFC
SSFL AREA II ALFA TEST AREA	NASA MSFC
TVC DESERVING FACILITY	NASA MSFC
TEST CELLS AND DATA RECORDING FAC.	NASA MSFC
TRANSIENT PRESSURE TEST FAC. 4515	NASA MSFC
TRIBOLOGY LAB	NASA MSFC
ELECTRIC PROPULSION 8417	DOD PL/ED
1-52 LARGE MOTOR COMPLEX	DOD PL/ED
1-32 MOTOR COMPONENTS COMPLEX	DOD PL/ED
1-14 SATELLITE ENGINE OPS.	DOD PL/ED
1-30 SOLID PROPELLANT LAB. AREA	DOD PL/ED

POWER AND PROPULSION CATEGORY 3B FACILITY INDEX (CONT.)

SYCAMORE CANYON-SITES B&D	GDC SPACE DIV.-SAN DIEGO
TEST FACILITY BLDG. 67	TRW -MANHATTAN BEACH
CTS	TRW-SAN CLEMENTE
B-AREA COMPONENT TEST STANDS	P&W-WEST PALM BEACH
D-AREA COMPONENT TEST STANDS	P&W-WEST PALM BEACH
E15-31 ROCKET COMPONENT TEST	P&W-WEST PALM BEACH
E-6 RL10 ALTITUDE TEST STAND	P&W-WEST PALM BEACH
E-8 HIGH PRESSURE FACILITY	P&W- WEST PALM BEACH
SKY TOP TEST FACILITY	NWC-CHINA LAKE
BAY 7	NWC-CHINA LAKE
T-24 TEST BAY	NWC-CHINA LAKE
T-97 TEST BAY	NWC-CHINA LAKE

POWER AND PROPULSION CATEGORY 3B FACILITY INDEX (CONT.)

POWER FACILITY	LOCATION
SPACE POWER FACILITY	NASA LeRC
SPACE LASER TEST STAND (SLTS)	BMDO/TRW CAPISTRANO
LASER APPLICATIONS LABORATORY	ARGONNE NAT. LAB.
TRANSIENT REACTOR TEST FACILITY (TREAT)	ARGONNE NAT. LAB.
ZERO POWER PHYSICS REACTOR	ARGONNE NAT. LAB.
SOLAR/THERMAL RADIATION LABORATORY	BOENG
SPACE & THERMAL ENVIRONMENTS LABORATORY	BOENG
THERMAL VACUUM LABORATORY	BOENG
HIGH ENERGY LASER LABORATORY	BOENG
POWER SYSTEMS LABORATORY	BOENG
SYSTEMS SIMULATION LABORATORY	COMSAT
SPACE POWER & EMA LABORATORY	GEN.DYN.SSD
SPACE SYSTEMS SIMULATION LABORATORY	GEN.DYN.SSD
SP100 GROUND TEST FACILITY	PAC.NW.LAB
POTASSIUM HEAT PIPE FILLING FACILITY	ROCKWELL
CTL III LASER FACILITY	ROCKWELL
SSFL SOLAR TEST FACILITY	ROCKWELL

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**MATERIALS, STRUCTURES AND FLIGHT DYNAMICS
WORKING GROUP**

FACILITY FINDINGS

SPACE R&D TASK GROUP

Materials & Structures and Flight Dynamics Working Group

Responsibility: Technical Areas of Responsibility

- Aerodynamics and Aerothermodynamics; Thermal Protection Systems; Structural Concepts & Large Space Structures; In-Space Environments; Vehicle GN&C (guidance, navigation & control); Controls-Structures Integration; Coatings & Advanced Materials; In-Space Materials Processing; etc.

Responsibility: Types of Facilities

- Avionics testbeds; Arc Jets (for TPS); Precision Structures testing; CSI testbeds; Computational Simulation Facilities (e.g., for CFD); Debris/Hypervelocity Testing; etc.
- Systems-level testing facilities associated with integrated aeromaneuvering vehicle testing; Micro-Gravity Simulation (e.g., drop towers for for Flight Experiments); etc.

General Comments

- This working group will be responsible for integrating program facility needs in the area materials & structures and flight dynamics related R&D and evaluating the appropriate facilities to meet those needs.
- This working group will be responsible for identifying common-ality or duplications in R&D needs or facilities between the technical working groups and making a recommendation to the R&S WG.

**MATERIALS, STRUCTURES AND FLIGHT DYNAMICS
WORKING GROUP**

CATEGORY 1A RECOMMENDATIONS

MATERIALS & STRUCTURES & FLIGHT DYNAMICS

CATEGORY 1A FACILITY INDEX

We have reviewed the Space R&D facilities available for use by National programs. Most of our attention was placed on government facilities. Five areas where action should be taken are recommended.

- Consolidate USAF Space Structures R&D Facilities**
- Replace Current Generation Micro-gravity Aircraft**
- Develop a 1-Meter Cold Optics Test Facility**
- New Facility for Processing Composite Materials & Structures**
- Endorse Hypersonics Working Group Recommendation to Develop a Liquid Hydrogen Structural Test Facility**

MATERIALS & STRUCTURES & FLIGHT DYNAMICS CATEGORY 1A FACILITY INDEX

FACILITY

LOCATION

**CARBON-CARBON PROCESSING
FILAMENT WOUND COMPOSITES
HIGH GAUSS MAGNETIC FIELD
MECHANICAL PROPERTIES TESTING
PULTRUSION FABRICATION
SMART STRUCTURES LAB
SPICE LAB
ASTREX
NDE FACILITY
KC-135
DC-9
LEAR JET**

**PHILLIPS LAB/ EDWARDS AFB
PHILLIPS LAB/ EDWARDS AFB
PHILLIPS LAB/ EDWARDS AFB
PHILLIPS LAB/ EDWARDS AFB
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PHILLIPS LAB/ EDWARDS AFB
PHILLIPS LAB/ EDWARDS AFB
JOHNSON SPACE CENTER
LEWIS RESEARCH CENTER
LEWIS RESEARCH CENTER**

Consolidate USAF Space Structures R&D Facilities

In the early 90's, when the Air Force consolidated from thirteen laboratories to four, responsibility for all of the space structures R&D work and facilities were assigned to the Phillips Laboratory. Unfortunately, however, the personnel and facilities doing this work were split between Kirtland AFB, NM, and Edwards AFB, CA, with over 700 miles in between. At Kirtland, the operations were originally in five buildings, with as much as four miles between buildings; at Edwards, the operations were originally in four buildings, with as much as one mile in between. (Currently, the numbers stand as six buildings at Kirtland and two at Edwards.) As part of its over-all consolidation plan, Phillips Laboratory subsequently proposed, and in FY92 received Secretary of the Air Force approval for, a plan that included constructing a new facility at Kirtland AFB, NM, to enable the geographic consolidation of this facilities into a single building.

The facilities being consolidated, listed on the page following this recommendation, provide both the offices and laboratories for the Air Force personnel who conduct research, exploratory development, and advanced development of the structures technologies for application to future space and ballistic missile applications. These facilities provide government personnel with the environment in which they can acquire hands on expertise in space structures and controls fabrication and experimentation. They are also used to provide support to on-going flight experiment programs being conducted by other parts of the Air Force Phillips Laboratory.

Under the supervision of the Army Corps of Engineers, this facility just went through its 100% design review in December 1993. Congress has already appropriated the money for the construction of the facility. The Air Force began moving personnel as part of this consolidation in the summer of 1993.

The principle payoff for this consolidation is elimination of inefficiency that is inevitable when an operation is fragmented and geographically separated. Additionally, by locating this activity at Kirtland with the majority of the rest of the Phillips Laboratory operation, the group will be more able to provide support to other Air Force activities, such as space experiments.

The implementation cost shown includes cost of facilities plus the cost of moving people and equipment into them. The operations & maintenance cost shown is the value anticipated for the new facility. The anticipated net savings has two parts. First, because the Air Force is on the path to build new facilities, some \$4 million in repairs and renovations (e.g., a \$1 M roof repair to cure a leaky roof problem at Edwards AFB) has been deferred. Second, because the plant equipment will be newer, the Air Force anticipates saving at least \$400,000 in annual maintenance costs.

CONSOLIDATE USAF SPACE STRUCTURES R&D FACILITIES

USAF

DESCRIPTION: In FY92, the Secretary of the Air Force approved a consolidation plan for the Phillips Laboratory; this plan included construction of a new facility at Kirtland AFB to consolidate all USAF space structures R&D facilities. Currently, USAF space structures R&D facilities are housed in two buildings at Edwards AFB, CA and six buildings at Kirtland AFB, NM. These facilities are used by USAF personnel to conduct research in spacecraft structural control and application of composite materials to USAF space and ballistic missile systems. They are also used to directly support on-going flight experiment programs at the Air Force Phillips Lab. The new facility is completely designed; ground-breaking will occur on March 29, 1994. Personnel moves from EAFB to KAFB were begun in FY93.

PAYOFF POTENTIAL:

- Improved efficiency over current operations.
- Improved support of and integration into Phillips mission.

COST SUMMARY: Implementation costs: \$15M

O&M Costs: \$0.2M

Anticipated net savings: \$4M repair/renovation + \$0.4M/FY

PROS:

- Improves support of and integration into Phillips mission
- Eliminates absentee supervisor problem

CONS:

- Cost of new facility

STEPS TO MAKE IT HAPPEN:

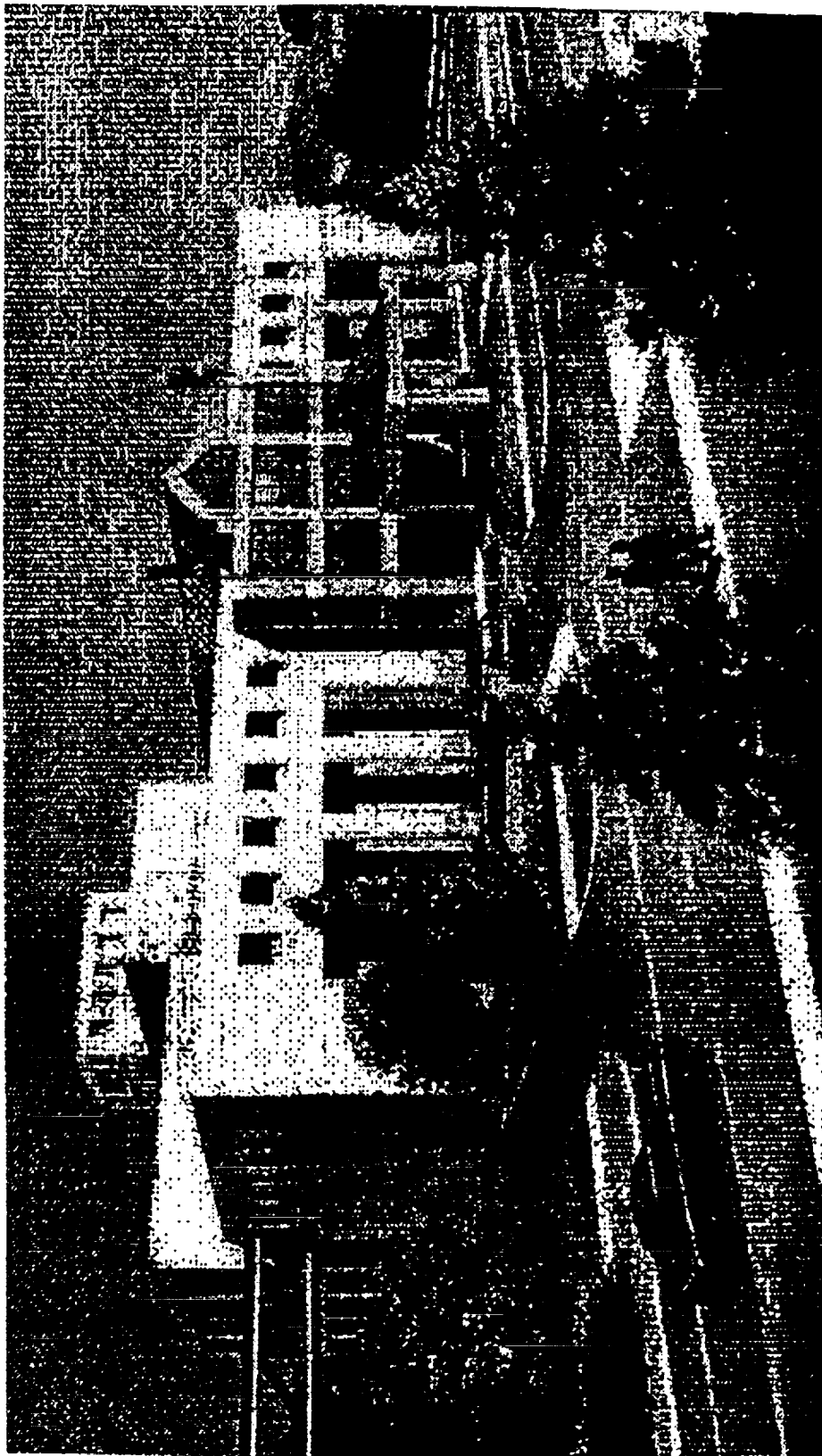
- CoE let contract to construct facility
- Move people & equipment following completion of construction

TASK GROUP RECOMMENDATION: Continue with AF consolidation as planned.

Date: 1/11/94

REV: 3/23/94

CATEGORY 1A



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Replace Current Generation Micro-Gravity Aircraft

The National Facilities Study Mission Model for microgravity research call for an expansion of activities as NASA moves toward the Space Station era. Participants in the use of microgravity facilities include various government, foreign, industrial and academic organizations. A key element of this research is activities conducted in low-gravity, parabolic flight, aircraft. The aircraft capabilities and future requirements have been extensively reviewed recently by NASA and has established the need for two large vehicles to accomplish its minimum objectives. Current activities are presently supported by a "high-time" KC-135 at the Johnson Space Center (JSC) and a Lear Jet at the Lewis Research Center (LeRC). NASA Code UG uses approximately 25% of the KC-135 time and a significant portion of the Lear Jet time. So it has been established that, because of the increased Code UG research and experiment development leading up to the Space Station, a plan has been developed to provide a DC-9 to replace the Lear Jet by the 4th quarter of FY94. It has been projected that the DC-9 will reach 100% utilization by FY96, and will provide a more expeditious program if located at the LeRC.

The KC-135 utilization will drop from the current 100% to 75% in July 1994 as the Code UG activity transfers to the DC-9. However, the KC-135 utilization will increase to 100% in the FY95 time frame as other Code U, Code C, and Space Station Crew Training activities increase. The "high-time" KC-135 aircraft is experiencing an increase in unplanned maintenance and therefore, it is essential that a "low-time" KC-135 be phased in during FY94 to accomplish the projected requirements. The cost of this upgrade will be approximately \$500K. These facilities have been and are projected to be extremely productive in advancing research and technology.

REPLACE CURRENT GENERATION MICRO-GRAVITY AIRCRAFT

NASA

DESCRIPTION: Large Low G Aircraft are key facilities for space R&D ranging from basic research through development and qualification of orbital flight hardware. This, combined with expanding activities associated with Space Station and continuing activities from DoD, Academia, and Industry requires an expanding capability to support projected research and development projects. To meet these requirements the current high time KC-135 should be replaced by a more reliable low time KC-135 from DoD inventory at JSC and the Lear Jet at LeRC should be replaced by a DC-9 with considerably more capability.

PAYOFF POTENTIAL:

- Ability to meet the expanding requirements for microgravity parabolic flight, reliably and efficiently.

COST SUMMARY: Implementation costs: \$2M (Preliminary)
Annual Costs: \$3.75M (Preliminary)

PROS:

- Accomplish the anticipated Research and Development activities in a timely and cost effective manner.
- Additional reliability of having two large aircraft to accomplish the mission.

CONS:

- Initial implementation cost

STEPS TO MAKE IT HAPPEN:

- Bring low time KC-135 and DC-9 online.
- Retire high time KC-135 and Lear Jet

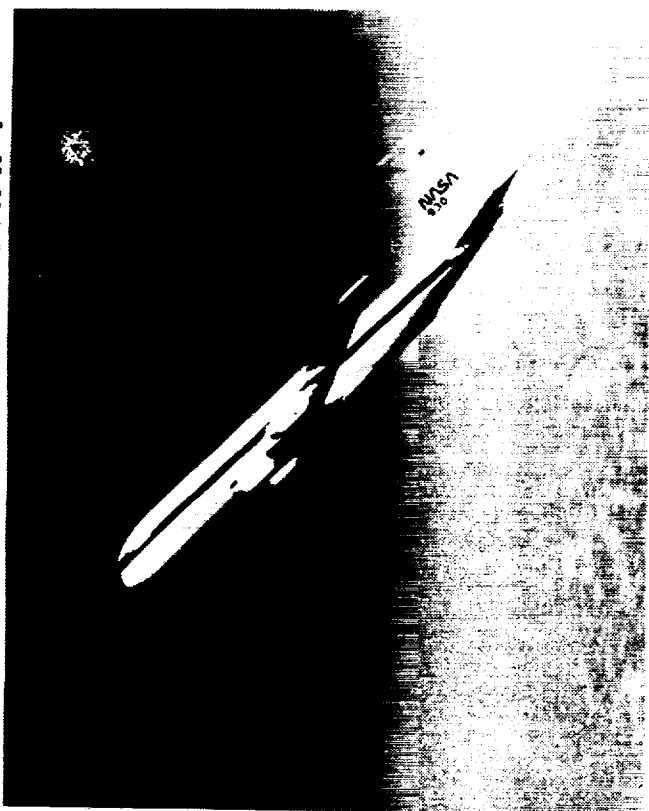
TASK GROUP RECOMMENDATION: Continue with current NASA plan.

Date: 1/11/94

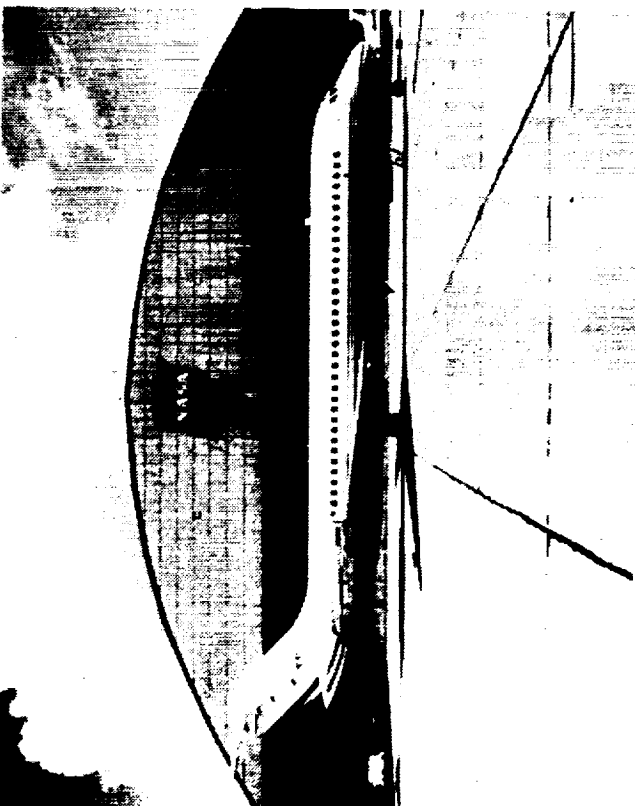
REV: 3/23/94

CATEGORY 1A

MICROGRAVITY AIRCRAFT



KC-135



DC-9



LEAR JET

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Develop a 1-Meter Cold Optics Test Facility

It is recommended that a new test facility be developed. The facility can be classified as a Cold Optics Development Laboratory that has the ability to provide liquid helium (2-3 Kelvin) temperature thermal soak capability. A thermal/vacuum jacketed liquid helium reservoir of sufficient size to accommodate a 1-meter diameter infrared telescope reflector is required for space applications.

Planned space science instruments such as SIRTf, STEP, GEM, EPCT, EOS can benefit from such a test facility. Low temperature development programs: telescope optics, (SWIR, MWIR, LWIR, SBMM), optical sensors, detectors, structures and mechanics, materials and others, would be potential candidates to utilize a low-temperature test facility.

An extensive survey of national facilities was conducted by staff engineers at the Jet Propulsion Laboratory in 1993 in an attempt to locate usable facilities. No government or commercial facilities were identified with capabilities greater than .5 meters. NASA Ames has a test facility currently in use that can accommodate reflector testing up to .5 meters, however, this facility is not expandable for large test specimens.

It is estimated that an existing thermal vacuum chamber of sufficient size could be modified to accommodate the low temperature requirements for about 3-5 million dollars. An entirely new facility would cost approximately 15 million dollars.

The primary function of a cold optics test facility would be to provide full scale distortion values for lightweight space borne reflectors, as well as the development of low temperature sensors and detectors.

This working group believes that this is a facility which should be considered for development in order to meet current and future NASA requirements.

DEVELOP A 1-METER COLD OPTICS TEST FACILITY

NASA/DOD

DESCRIPTION: Thermal/Vacuum jacketed liquid helium reservoir of sufficient size to accommodate a 1 meter diameter infrared telescope reflector for space applications, (2-3 deg Kelvin). This facility is driven by the baseline mission model.

PAYOFF POTENTIAL:

- Planned space science instruments such as SIRTf cannot be accommodated in existing facilities as the result of size limitations.

COST SUMMARY:

Implementation costs: Modification of an existing thermal vacuum chamber at a cost of 3-5 million dollars or the construction of a new facility at a cost of 5-15 million dollars.

PROS:

- Provide full scale distortion values for lightweight reflectors.
- Existing Thermal Vacuum facilities can be altered to accommodate requirements.
- Establish a Cold Optics Development Lab for future, planned programs.

CONS:

- Dollar investment in new technology
- Requires program support (dollars)

STEPS TO MAKE IT HAPPEN:

- Mission From Planet Earth Associate Administrator should assemble a team of experts to assess program need for the facility
- Based on above result, develop facility requirements, including any DoD requirements

TASK GROUP RECOMMENDATION: Proceed with above steps.

Date: 1/11/94

REV: 3/23/94

CATEGORY 1A

New Facility for Processing Composite Materials & Structures

The curing of an organic composite with an electron beam or high energy x-ray is nearly instantaneous under the beam. The time to cure a composite part is literally the time required to uniformly move the part under the beam. The time to cure very large parts is measured in minutes. Typical autoclave or oven cure ranges from 8 hours to several days. Power required is a fraction of that required for conventional curing. Electron beam curing is not a thermal process and does not require the heat-up of a large autoclave or oven, tooling and component. The primary power requirement is for the electron beam which is in operation only 5-10 minutes for a large component. Autoclave facilities for curing large structures cost \$30-\$50M and are costly to use and maintain. A comparable electron beam facility will cost \$15-\$20M with little maintenance. More complex composite structural and material architectures are possible such as more optimum unbalanced layouts. Thermal distortion does not occur because the cure is accomplished at ambient temperature.

The range of usable tooling materials expands tremendously when the composite cure is done at ambient temperature. Materials such as wood, plastic, aluminum, and foam can be used without concern for thermal expansion, loss of mechanical properties, or thermal stresses. Tooling cost reductions over 90% are achievable.

This facility would provide a national R&D facility for electron beam technology. The group recommends that the AACB Launch Vehicle Panel conduct a study, with membership from industry and government, to define facility details.

NEW FACILITY FOR PROCESSING COMPOSITE MATERIALS & STRUCTURES

NASA/DOD

DESCRIPTION: Provide the U.S. with a national facility capable of high energy electron beam or X ray processing/curing of composite materials. There is currently no facility in the U.S. beyond small laboratory scale. France has the world's only large scale production facility. This facility is driven by the requirements from the excursion to develop a new launch system. This facility could also have benefits for aeronautics, in particular international competitiveness implications.

PAYOFF POTENTIAL:

- Significant reduction (over 90%) in processing cost (time, power, facilities, manpower)
- Enabling for complex structural architecture.
- Enables levels of structural precision not obtainable today. (ambient temperature cure)
- Significant reduction in tooling complexity, risk and costs.
- Significant reduction in processing risk.
- Structure size not limited by size of costly autoclave or oven.

COST SUMMARY: Implementation costs: \$15M (single national facility)

Annual Costs: \$TBD (government and commercial research)

PROS:

- Provides national research facility in electron beam technology.
- Significant impact on application and quality of composites.
- Encourages industry acceptance of radical new technology.
- Provides data for industry investment decisions.

CONS:

- Gov't cost of building, maintaining and operating.
- Change in industry's old technology base.

STEPS TO MAKE IT HAPPEN:

- Task the AACB Launch Vehicle Panel to conduct a study (membership to include industry & government) to define the facility details (location, size, etc.).

TASK GROUP RECOMMENDATION: Proceed with AACB-led study.

Date: 1/11/94

REV: 3/23/94

CATEGORY 1A

Endorse Hypersonics Working Group Recommendation To Develop a Liquid Hydrogen Structural Test Facility

Test requirements for flight vehicle structures typically consist of coupon test, small component tests, major component tests, and complete vehicle tests. The major difference between conventional structural testing and that required for aerospacecraft structures is the inclusion of thermal loads and cryogenics. Combined thermal and mechanical loading are important, and liquid hydrogen is necessary in the tests because no other cryogenic fluid can adequately simulate liquid hydrogen. For hypersonic vehicles and most space transportation systems, elevated temperature and cryogenic conditions should be added to most structural tests. The facility recommended by the hypersonics working group would accommodate major full-scale components under combined mechanical and thermal loading with cryogenics including liquid hydrogen.

The Space R&D Materials & Structures & Flight Dynamics Working Group endorses this development of this facility to meet the requirements from the excursion that would develop a space transportation system. This facility would not be required, from a space R&D perspective, for the baseline mission model.

ENDORSE HYPERSONICS WORKING GROUP RECOMMENDATION TO DEVELOP A LIQUID HYDROGEN STRUCTURAL TEST FACILITY

NASA/DOD

DESCRIPTION: The facility recommended by the hypersonics working group provides thermal-structural testing of major full-scale components. The requirement, from a space R&D perspective, is the excursion that develops a new launch vehicle. The baseline mission model would not require this facility.

PAYOFF POTENTIAL:

- Provides near-term data to support Hypersonics R&D
- Provides near-term data to support advanced launch vehicle systems concepts

COST SUMMARY: Implementation costs: \$25M
O&M Costs: TBD

PROS:

- Reduced development risk
- Allows verification of new technology developments

CONS:

- Cost of new facility

STEPS TO MAKE IT HAPPEN:

- Provide funds to construct facility

TASK GROUP RECOMMENDATION: Implement plan developed by Aeronautics Task Group

Date: 1/11/94

REV: 3/23/94

CATEGORY 1A

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**MATERIALS, STRUCTURES AND FLIGHT DYNAMICS
WORKING GROUP
CATEGORY 1B RECOMMENDATIONS**

III - 67

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Aero/Thermal/Structural Loads Facilities

Aero/thermal/structural loads facilities are primarily used in the area of reentry heating simulations which involve high-temperature materials tests of thermal protection systems (TPS). The arc jet facilities simulate critical environmental conditions associated with entry into atmospheres including high temperature gas chemistry, heating rates, and surface pressures. The radiant heat test facility simulates ascent heating and pressure decay, on-orbit cold soak, and reentry heating and pressure. These facilities are presently being used to support the Shuttle program and advanced TPS technology developments. They would also be used extensively for any new space transportation system development.

We have reviewed the attached list of Aero/Thermal/Structural Loads Facilities and feel that they are required to meet the mission model (both baseline and excursions) both now and in the foreseeable future. Based on our review and analysis of data received, this group concludes that these facilities are integral to the mission of the organizations at which they are located. We have not addressed the issues of standard maintenance or improvements and modernization (I & M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements. This group sees no advantages for consolidations and/or closures of these facilities unless there is a realignment/redefinition of the owning organization roles and mission.

AERO/THERMAL/STRUCTURAL LOADS FACILITIES

Facility	Center
Direct Connect Arc Heated Facility	AMES RESEARCH CENTER
Interactive Heating Facility	AMES RESEARCH CENTER
Panel Test Facility	AMES RESEARCH CENTER
Aerodynamic Heating Facility	AMES RESEARCH CENTER
Laboratory Testing Area	JOHNSON SPACE CENTER
Radiant Heat Test Facility	JOHNSON SPACE CENTER
Arcjet Facility	PHILLIPS LAB / EDWARDS AFB

Materials Processing Facilities

The National Facilities Study Mission Model calls for evolutionary materials and process improvement to support future military, civil, and commercial payloads. At the systems level, the following improvements will be required:

- reduction in the fraction of satellite weight associated with structure
- cost of satellite assembly
- dynamic stability/pointing accuracy
- composites outgassing/contamination

These requirements will drive the development of ultra-lightweight structural materials, lightweight fittings, hinges and assemblies and accelerate the development and application of smart or multi-use materials and structures.

The materials and processing facilities evaluated by the working group involved four NASA Centers, two DoD locations, and two DOE locations. These facilities are involved in a wide range of materials and process work including metals joining, micromeroid testing and analysis, graphite epoxy, graphite thermoset and ceramic composite processing, materials process control, fatigue and fracture behavior including micro-cracking of composites, hyergolic propellant compatibility testing, rubber seal development and characterization, propellant mixing, failure analysis, outgassing/contamination evaluation of materials, materials modelling, and a full range of materials characterization capabilities including stress, strain, density, conductivity, hysteresis, etc.

From the information provided, it was concluded that many of the facilities support dedicated programs at the centers or laboratories involved coupled with the fact that many support both space and aeronautical work. All of the facilities reviewed have reasonably high utilization rates, and low operation and maintenance costs. As a result of these factors, plus a view by the working group that these facilities are integral to the mission of the organizations involved and would not yield significant savings from facility consolidation, the working group listed this grouping of facilities as category 1B - no change.

MATERIALS PROCESSING FACILITIES

Facility	Center
Materials and Processing Center	AMES LABORATORY (USDOE)
Metallurgical laboratory	JOHNSON SPACE CENTER
Alloys Development Laboratory	JOHNSON SPACE CENTER
Chemistry Laboratory	JOHNSON SPACE CENTER
Metallurgical Engineering Laboratory	JOHNSON SPACE CENTER
Materials Test Facility	JOHNSON SPACE CENTER
Plastics & Advanced Composite Facility	LAWRENCE LIVERMORE NAT'L LAB
Mechanical & Corrosion Testing	MARSHALL SPACE FLIGHT CENTER
Metallurgical Diagnostics Facility	MARSHALL SPACE FLIGHT CENTER
Ceramics Coatings & High Temp Mat'l's Lab	MARSHALL SPACE FLIGHT CENTER
Rubber Fabrication Laboratory	MARSHALL SPACE FLIGHT CENTER
Advanced Bonding Technology Laboratory	MARSHALL SPACE FLIGHT CENTER
Composites Development Facility	MARSHALL SPACE FLIGHT CENTER
Computed Tomography Facility	MARSHALL SPACE FLIGHT CENTER
Filament Winding and Pultrusion Laboratory	MARSHALL SPACE FLIGHT CENTER
Robotic Welding Facility	MARSHALL SPACE FLIGHT CENTER
	MARSHALL SPACE FLIGHT CENTER
	MARSHALL SPACE FLIGHT CENTER
Tape Laying & Fiber Placement Facility	MARSHALL SPACE FLIGHT CENTER
Vacuum Plasma Spray Facility	MARSHALL SPACE FLIGHT CENTER
Mechanical Properties/Creep Testing Facility	MARSHALL SPACE FLIGHT CENTER
Materials Joining	OAK RIDGE
Structures & Properties of Surfaces & Interfaces	OAK RIDGE
	OAK RIDGE
	OAK RIDGE
Precision Machining and Grinding Center	OAK RIDGE
CARBON-CARBON PROCESSING	PHILLIPS LAB / KIRTLAND AFB
FILAMENT WOUND COMPOSITES	PHILLIPS LAB / KIRTLAND AFB
HIGH GAUSS MAGNETIC FIELD FACILITY	PHILLIPS LAB / KIRTLAND AFB
MECHANICAL PROPERTIES TESTING	PHILLIPS LAB / KIRTLAND AFB
PULTRUSION FABRICATION	PHILLIPS LAB / KIRTLAND AFB

Environmental Effects Facilities

The environmental effects facilities evaluated in this study are directly applicable to all of the National Facilities Study Mission Models. The facilities covered by this category include those capable of simulating the various parameters (radiation, atomic oxygen, meteoroids/debris, etc.) in both the space and terrestrial environments, and evaluating the effects of these parameters on small spacecraft subcomponents, primarily in support of materials and protective coatings research. The government facilities reviewed in this study included those from NASA, DOD, and DOE Laboratories, and ranged from single parameter exposure facilities to multiparameter exposure facilities.

After reviewing the facilities in the database, the panel has concluded that they are adequate and required to meet the mission model in the baseline and excursions. We have not addressed the issues of standard maintenance or improvements and modernization (I & M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements. The facilities reviewed are integral to the mission of the organizations at which they are located and for several facilities are utilized by industry and academia for development and research activities. This group sees no advantages for consolidations and/or closures of these facilities unless there is a realignment/redefinition of the owning organization roles and mission. In summary, the panel recommends the Environmental Effects category as 1B - No Change.

Environmental Effects Facilities

Facility	Center
G Range	ARNOLD ENGINEERING DEVELOPMENT CENTER
Impact Range	ARNOLD ENGINEERING DEVELOPMENT CENTER
S-1 Impact Range	ARNOLD ENGINEERING DEVELOPMENT CENTER
Radiation Effects Facility	BROOKHAVEN NATIONAL LABORATORY
183-214, Atomic Oxygen Test Facility	JET PROPULSION LAB
Space Environment Effects Laboratory	JOHNSON SPACE CENTER
Environmental Simulation Testing Laboratory	JOHNSON SPACE CENTER
Hypervelocity Test Facility	JOHNSON SPACE CENTER
SEEF: Atomic Oxygen & Solar UV Laboratory	MARSHALL SPACE FLIGHT CENTER
SEEF: Charged Particle Radiation & Solar UV Lab	MARSHALL SPACE FLIGHT CENTER
Space Debris Impact Facility	MARSHALL SPACE FLIGHT CENTER
Environmental Testing Laboratory #8120	STENNIS SPACE CENTER

Structural Dynamics, Acoustics, and Vibration Test Facilities

Structural dynamics, acoustics, and vibration test facilities are primarily used in acoustic and vibration testing of components and complete spacecraft, and modal testing of spacecraft and launch vehicles. In terms of size of test article, the modal test facility at the MSFC is unique (as will be discussed in a later chart) and can accommodate a launch vehicle, and the acoustic test facility at the JSC can accommodate a large spacecraft. These facilities, in particular, would be needed for current and future hardware development. There are also several major facilities at the LaRC and the Phillips Lab where advanced technology development is being conducted on control of flexible structures.

We have reviewed the attached list of structural dynamics, acoustics, and vibration test facilities and feel that they are required to meet the mission model (both baseline and excursions) both now and in the foreseeable future. Based on our review and analysis of data received, this group concludes that these facilities are integral to the mission of the organizations at which they are located. We have not addressed the issues of standard maintenance or improvements and modernization (I & M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements. This group sees no advantages for consolidations and/or closures of these facilities unless there is a realignment/redefinition of the owning organization roles and mission.

STRUCTURAL DYNAMICS, ACOUSTICS AND VIBRATION TEST FACILITIES

Facility	Center
Acoustics Test Facility	JET PROPULSION LAB
Dynamics Test Facility	JET PROPULSION LAB
Vibration and Acoustic Test Facility	JOHNSON SPACE CENTER
Spacecraft Structures Research Lab	LANGLEY RESEARCH CENTER
Structural Dynamics Research Lab	LANGLEY RESEARCH CENTER
Structural Dynamics Laboratory, Bldg. 56	LEWIS RESEARCH CENTER
Dynamic Test Tower	MARSHALL SPACE FLIGHT CENTER
Ground Experiment Control Laboratory	MARSHALL SPACE FLIGHT CENTER
Acoustic Test Facility	MARSHALL SPACE FLIGHT CENTER
Control Dynamics Facility	MARSHALL SPACE FLIGHT CENTER
Modal Test Facility	MARSHALL SPACE FLIGHT CENTER
Pyrotechnic Shock Test Facility	MARSHALL SPACE FLIGHT CENTER
Vibration Test Facility	MARSHALL SPACE FLIGHT CENTER
SMART STRUCTURES LAB	PHILLIPS LAB / KIRTLAND AFB
SPICE LAB	PHILLIPS LAB / KIRTLAND AFB
ASTREX	PHILLIPS LAB / KIRTLAND AFB
Vibration Laboratory #8120	STENNIS SPACE CENTER
Vibration Laboratory	WALLOPS FLIGHT FACILITY/GSFC
IVA (Impact, Vibration, Acceleration) Facility	ARNOLD ENGINEERING DEVELOPMENT CENTER

Structural Loads/NDE Facilities

We have reviewed the attached list of Structural Loads/NDE Facilities and feel that they are required to meet the mission model both now and in the foreseeable future. We have not addressed the issues of standard maintenance or improvements and modernization (I & M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements.

Structural Loads Facilities are required to certify either actual or scaled-versions of large space structures and/or their components under simulated mission load histories. Each facility has its own set of unique capabilities (i.e., test component aspect ratio [length-to-width ratio], loading actuator capacities, etc.) that are not duplicated anywhere else. Each facility has a pool of personnel that are shared among several other facilities in their respective complexes, and therefore, cost savings would be minimal if these facilities were consolidated/closed. Finally, reported utilization rates for these facilities are above 75 percent; for this type of facility a utilization rate above 75% (considering set-up time and maintenance schedules) should be considered fully utilized.

In our review of the Structural Loads Facilities, we have identified the LTA facility at MSFC as a National asset. This facility will be necessary for the excursions from the baseline model that include the development of a new space transportation system. We feel that due to its capability of testing extremely large space structures and its high replacement costs, it would be in the Nation's best interest to maintain this facility in its present condition such that it could be brought up to its operational capability with a modest investment in time and funding.

NDE Facilities are required to identify flaws and defects that will impair the structural integrity of our space structures and their components. These facilities provide us with vital information that will influence decisions on flight worthiness of a particular structure. We know that these facilities will be necessary as more advanced materials (i.e., metal matrix & ceramic matrix composites) are substituted for conventional monolithic materials in space applications. All of these facilities are equipped to handle large structures, have low operation and maintenance costs, and are utilized over 75% of the time.

Based on our review and analysis of data received, this group concludes that these facilities are integral to the mission of the organizations at which they are located. This group sees no advantages for consolidations and/or closures of these facilities unless there is a realignment/redefinition of the owning organization roles and mission.

Structural Loads/NDE Facilities

Facility	Center
Center for Nondestructive Evaluation	AMES LABORATORY (USDOE)
Structures Test Facility	JOHNSON SPACE CENTER
Mechanisms Development Facility	MARSHALL SPACE FLIGHT CENTER
(Non-Optical) NDE Facility	MARSHALL SPACE FLIGHT CENTER
LTAE Universal Test Machine	MARSHALL SPACE FLIGHT CENTER
Load Test Annex (LTA)	MARSHALL SPACE FLIGHT CENTER
Load Test Annex Extension (LTAE)	MARSHALL SPACE FLIGHT CENTER
NON-DESTRUCTIVE EVALUATION FACILITY	PHILLIPS LAB / KIRTLAND AFB

Avionics Facilities

Avionics facilities are primarily used for flight software and hardware development associated with flight control systems. Examples of hardware development include flight computers, sensors, interface electronics, etc. Typically, hardware-in-the-loop simulations are conducted in avionics facilities. Most of the present avionics facilities are focussed on space transportation systems. They would be used extensively for any new space transportation system development.

We have reviewed the attached list of Avionics Facilities and feel that they are required to meet the mission model (both baseline and excursions) both now and in the foreseeable future. This includes both single-stage-to-orbit concepts, as well as multiple-stage-to-orbit concepts. Based on our review and analysis of data received, this group concludes that these facilities are integral to the mission of the MSFC to provide leadership in developing a new space transportation system for the nation. Location of these facilities at the MSFC is considered mandatory in order to effectively provide program support in the areas of technology, concept development, hardware evaluation, and integrated simulations. We have not addressed the issues of standard maintenance or improvements and modernization (I & M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements. This group sees no advantages for consolidations and/or closures of these facilities unless there is a realignment/redefinition of the owning organization roles and mission.

AVIONICS FACILITIES

Facility	Center
Control Moment Gyro Test & Evaluation Laboratory	MARSHALL SPACE FLIGHT CENTER
Software Development & Technology Laboratory	MARSHALL SPACE FLIGHT CENTER
AXAF-S Avionics Simulation Laboratory	MARSHALL SPACE FLIGHT CENTER
Flight Simulation Lab	MARSHALL SPACE FLIGHT CENTER
Marshall Avionics Systems Testbed (MAST)	MARSHALL SPACE FLIGHT CENTER
Next Generation Launch Vehicle Simulation Lab	MARSHALL SPACE FLIGHT CENTER

Microgravity Facilities

We have reviewed the attached list of Microgravity Facilities and feel that they are required to meet the mission model both now and in the foreseeable future. Microgravity facilities are required for research, orbital flight hardware development, and crew training. The drop towers and drop tubes are managed and reviewed by NASA Headquarters to support ongoing and projected research and development of new areas of science and supporting hardware. The aircraft capabilities and future requirements have been extensively reviewed by NASA in the recent past and established the need for two large aircraft. We have not addressed the issues of standard maintenance or improvements and modernization (I & M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements.

Based on our review and analysis of data received, this group concludes that these facilities are integral to the mission of the organizations at which they are located and provide the required support for microgravity activities of all NASA, DoD, academia, and industry. This group sees no advantages for consolidations and/or closures of these facilities unless there is a realignment/redefinition of the owning organization roles and mission.

MICROGRAVITY FACILITIES

Facility	Center
2.2 Second Drop Tower, Bldg. 45	LEWIS RESEARCH CENTER
Space Experiments Laboratory, Bldg. 110	LEWIS RESEARCH CENTER
Zero Gravity Research Facility, (Bldg. 110)	LEWIS RESEARCH CENTER
Drop Tower Facility (Deactivated)	MARSHALL SPACE FLIGHT CENTER
Drop Tube Facility	MARSHALL SPACE FLIGHT CENTER
Microgravity Development Complex	MARSHALL SPACE FLIGHT CENTER

Spacecraft Integration Facilities

We have reviewed the attached list of spacecraft integration facilities and feel that they are adequate and required to meet the mission model in the baseline and in the excursions. We have not addressed the issues of standard maintenance or improvements and modernization (I & M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements.

Based on our review and analysis of data received, this group concludes that these facilities are integral to the mission of the organizations at which they are located. There is evidently no excess capability, but there is also little, if any, coordination among the government facilities to ensure a distribution of work that would be beneficial to the government. This group sees no advantages for consolidations and/or closures of these facilities unless there is a realignment/redefinition of the owning organization roles and mission, but recommend that a coordination effort be established.

This group supports the concept of in-house government manufacturing of prototype or one-of-a-kind research satellites as being advantageous to the nation. In these cases, most contracting and paperwork requirements are greatly reduced, making quick-response and redirection much easier and less expensive compared with contracting with private industry.

This group further recommends that the Air Force and DoE continue on-going efforts to coordinate utilization, modification, and build up of spacecraft integration facilities on Kirtland AFB, NM.

Spacecraft Integration Facilities

<u>FACILITY</u>	<u>LOCATION</u>
Spacecraft Sys Dev Integ Facility	GSFC
Spacecraft Assembly Facility	JPL
Systems & Payloads Test Facility	MSFC
Aerospace Engineering Facility/ Space Experimental Integration Facility*	PL
Spacecraft Manufacturing & Test Facility*	NRL
TBD*	APL
TBD (Bldg 963)*	SNL

* Not in database

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**MATERIALS, STRUCTURES AND FLIGHT DYNAMICS
WORKING GROUP**

CATEGORY 2 RECOMMENDATIONS

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Large Thermal Vacuum Chambers

Large thermal vacuum chambers give us the nearest simulation of the space environment that can be achieved short of orbit at orders of magnitude less cost: as a result, they are key facilities for space R&D ranging from basic research through system qualification testing. In the past, when the U.S. civil space program was reaching for the moon and planets and while the U.S. military space program was preparing for conflict with a major global power, industry and government were facilitated for needs which may be far beyond those in the future. As a result, a careful study of consolidation of these assets may result in savings for all agencies.

This group attempted to focus on major assets with significant cost implications. As a result, rather than looking at every "chamber"....which could include bell jars that fit on a lab bench, we established our own criteria of 10 ft. in diameter and 20 ft. in length as our threshold values for study. The chart following the facing page gives a list of just these facilities.

Though this working group suspected that there is an excess capacity of thermal vacuum chambers, we did not believe we were properly constituted to make an accurate, authoritative determination in this area. Thermal vacuum chambers are used by more technical disciplines than the structures and materials and flight dynamics represented on this working group: propulsion, human factors/life support, et. al., also use some of the same facilities. Additionally, these facilities are used by spacecraft developers and manufacturers for qualification. To make a proper judgement, we strongly believe that broader representation from these other areas is needed. Hence, our recommendation for further study.

Neither the exact costs associated with this recommendation, nor the savings from its implementation can be estimated with any certainty until details are more fully established. However, there is a potential for cost savings, through reduction of operations and maintenance costs and elimination of duplicate or unneeded improvement and modernization costs. To achieve these savings, the organizations currently owning these facilities will almost assuredly have to face the issues of job losses and mission changes. Consolidation would also reduce the total national capacity for thermal vacuum work, though the group believes that there is excess capacity.

We recommend that a special study group be convened under the sponsorship of the AACB to look at the thermal vacuum chamber inventory and better establish requirements. As stated above, we strongly believe that all the users and operators should be represented to get credible results. We further recommend that construction of new large (10 ft. diameter, 20 ft. length) vacuum chambers, or major modification of existing chambers (Johnson Spaceflight Center's Chamber A, for example) be deferred until this study group reports.

LARGE THERMAL VACUUM CHAMBERS

DESCRIPTION: Large Thermal Vacuum Chambers are key facilities for space R&D (from basic research through qualification testing). This, combined with the large number of satellites produced in the cold war/aggressive civil government space program of the past has resulted in a large inventory of chambers (both government and commercial) which may exceed the requirements of the baseline (and excursions) mission model.

PAYOFF POTENTIAL:

Improved operations from optimizing infrastructure and procedures with savings to all agencies.

COST SUMMARY: Implementation Cost TBD
 Annual Savings or Cost TBD

PROS:

- Potential Cost Savings (Reduced O&M and duplicate I&M)
- Rice Bowls & Turf Battles
- Decreased Total National Capability (Excess Capacity?)

STEPS TO MAKE IT HAPPEN:

- Convene special study group under the auspices of the AACB
 - Membership should include industry & government, facility users and operators, and representatives from all the "technical disciplines" involved/impacted (propulsion, spacecraft manufacturers, human factors/life support, structures, et. al.)

TASK GROUP RECOMMENDATIONS:

- Conduct Study
- Assuming the recommended study is initiated, then defer construction or modification (e.g., JSC Chamber A) of new, large vacuum chambers pending results of this study

Date: 1/11/94

REV: 3/23/94

CATEGORY 2

THERMAL VACUUM CHAMBERS

Facility	Center
Space Environment Simulator, Facility 290	GODDARD SPACE FLIGHT CENTER
Thermal Vacuum Chamber, facility 225	GODDARD SPACE FLIGHT CENTER
Thermal/Vacuum Test Facility	JET PROPULSION LAB
25-Ft Space Simulator	JET PROPULSION LAB
10-Ft Space Simulator	JET PROPULSION LAB
Chamber A	JOHNSON SPACE CENTER
Chamber B	JOHNSON SPACE CENTER
Thermal vacuum test facility	LAWRENCE LIVERMORE NAT'L LAB
Vacuum Facility 5 (VF-5)	LEWIS RESEARCH CENTER
Vacuum Facility 6 (VF-6)	LEWIS RESEARCH CENTER
Altitude Test Chambers	MARSHALL SPACE FLIGHT CENTER
High Vacuum Space Simulation Chambers	MARSHALL SPACE FLIGHT CENTER
Space Environmental Facility	PHILLIPS LAB / KIRTLAND AFB
Thermal Vacuum and Space Simulation Laboratory	WALLOPS FLIGHT FACILITY/GSFC
AEDC 7V/10V Environmental Chambers	BMDO
12V Aerospace Chamber	ARNOLD ENGINEERING DEVELOPMENT CENTER
4 X 10 Test Chamber	ARNOLD ENGINEERING DEVELOPMENT CENTER
7A Component Checkout Chamber	ARNOLD ENGINEERING DEVELOPMENT CENTER
Space Materials Outgassing (SMOG) Chamber	ARNOLD ENGINEERING DEVELOPMENT CENTER
Ultra-High Vacuum (UHV)	ARNOLD ENGINEERING DEVELOPMENT CENTER
Thermal Vacuum Test Facility - 351	JOHNSON SPACE CENTER
16-Meter Thermal Vacuum Chamber	LANGLEY RESEARCH CENTER
	LEWIS RESEARCH CENTER
Thermal / Vacuum Chamber	NAVAL RESEARCH LABORATORIES
Thermal / Vacuum Chamber	DEPARTMENT OF ENERGY
Thermal / Vacuum Chamber	GODDARD SPACE FLIGHT CENTER
Thermal / Vacuum Chamber	GODDARD SPACE FLIGHT CENTER
Thermal / Vacuum Chamber	LEWIS RESEARCH CENTER
Thermal / Vacuum Chamber	LEWIS RESEARCH CENTER
Thermal / Vacuum Chamber	LEWIS RESEARCH CENTER
Thermal / Vacuum Chamber	LEWIS RESEARCH CENTER
Thermal / Vacuum Chamber	LEWIS RESEARCH CENTER
Thermal / Vacuum Chamber	LEWIS RESEARCH CENTER
Thermal / Vacuum Chamber	LEWIS RESEARCH CENTER
Thermal / Vacuum Chamber	MARSHALL SPACE FLIGHT CENTER
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Spacecraft Integration Facilities

In our Category 1B recommendation on Spacecraft Integration Facilities, this group has already stated that the existing facilities are both required and sufficient to support both the baseline and excursions to the study mission model. We also concluded that these facilities are critical to the owning organizations with their current missions. Nonetheless, the sheer number of government organizations doing work in this area (in which the government is committed to reliance on industry for production systems) led this group to question the number of roles and missions overlaps both within and between agencies. The involvement of the Department of Energy Labs in spacecraft integration and of NASA in energy efficient cars is a good example of the overlaps that we observed. Our group strongly believes that rational facility decisions are based on the roles and missions of involved organizations; as a result, we believe that roles and missions must be addressed before any of the involved government spacecraft integrators can rationally be asked to give up these facilities.

The potential payoff of redefining roles and missions is a better optimization of infrastructure to meet future US space mission needs, potentially reducing costs for all agencies involved. Neither the costs to consolidate operations nor the savings arising from a consolidation can be quantified without a better understanding of what actually will be combined.

The potential for reducing operations, maintenance, improvement and modification costs are the biggest argument for consolidating some operations. On the negative side, the danger of eliminating jobs in a consolidation will be an impediment to any consolidation of activity, as will the commitment of the involved organizations to their current missions. The other major negative is the fact that any consolidation of these activities will lead to a decrease in a total national capability that this group found fully required by the current mission model; the group believes that when government and industry facilities are combined there may, in fact, be an excess in national capacity.

To resolve this issue, the group recommends that a special study group be convened under the auspices of the AACB to look at roles and missions across the board in space technology. We recommend that membership should include industry, government, and academia. Facility owners, operators, and users, as well as system operators, should be represented on the group.

SPACECRAFT INTEGRATION

DESCRIPTION: As already discussed, this group concluded that the existing Spacecraft Integration Facilities are adequate and required to meet the mission model in the baseline and in the excursions. Additionally, we concluded that these facilities are integral to the mission of the organizations at which they are located. While there is evidently no excess capability based on the mission model, the sheer number of government organizations doing this work points to both inter- and intra- agency roles and missions overlaps.

PAYOFF POTENTIAL:

Improved operations from optimizing infrastructure and procedures with savings to all agencies.

COST SUMMARY:	Implementation Cost	TBD
	Annual Savings or Cost	TBD

PROS:

- Potential Cost Savings (Reduced O&M and duplicate I&M)

CONS:

- Rice Bowls & Turf Battles
- Decreased Total National Capability (Excess Capacity?)

STEPS TO MAKE IT HAPPEN:

- Convene special study group under the auspices of the AACB to study roles and missions across the board in space technology
 - Membership should include industry & government, facility users and system operators

TASK GROUP RECOMMENDATIONS:

- Conduct Study

Date: 1/11/94

REV: 3/23/94

CATEGORY 2

Unique National Facility Assets

In the course of this study, the group identified several facilities that we believe worthy of recognition as truly national assets. These facilities, their location, and what makes them unique are summarized on the opposite page.

The MSFC has two facilities which the group believes will be critical to development of a new launch system under either of the launch system excursions of the mission model. The Dynamic Test Facility and the Loads Test Annex Facility are both large dollar replacement value facilities that saw extensive use in the Shuttle program and will be the facilities used for the same purpose on any new launch system effort conducted by the US.

The JSC Chamber B is the largest man-rated thermal vacuum chamber in the world. As such, it is seeing extensive use currently in support of the space station program and supporting technologies.

The JPL has a 25-ft thermal vacuum chamber with an ultra-high fidelity solar simulator. The ultra-high fidelity solar simulator was developed for approximately \$15M in support of the JPL interplanetary programs, but has become an internationally recognized facility. Virtually every commercial geosynchronous communication satellite has had its first model tested in this JPL chamber to confirm performance and validate models and tests from other chambers. The Dutch have recently used this chamber as their benchmark for a new facility they are building.

The LeRC large thermal vacuum chamber at Plumbrook is also a unique national asset. Like the MSFC facilities discussed above, the group believes that this facility will be critical to development of a new launch system under either of the launch system excursions of the mission model. The facility was used for testing of the payload shroud on the Titan IV program; this group sees the Plumbrook facility being used for the same kind of tests in a new launch system development.

UNIQUE NATIONAL FACILITY ASSETS

<u>Facility</u>	<u>Location</u>	<u>Uniqueness</u>
Dynamic Test Facility	MSFC	Size
Loads Test Annex Facility	MSFC	Size
Chamber B	JSC	Man-Rated
25 Ft Thermal Vacuum Chamber	JPL	Solar Simulator
Thermal Vacuum Chamber	Plumbrook	Size

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**HUMAN AND MACHINE OPERATIONS
WORKING GROUP**

FACILITY FINDINGS

SPACE R&D TASK GROUP

Human & Machine Operations Working Group

Responsibility: Technical Areas of Responsibility

- Life Support Systems; Extravehicular Activity (EVA) Systems; Human Factors; Robotics and Teleoperation; Artificial Intelligence; In-Space Assembly and Operations; Autonomous Vehicles (e.g., Autonomous Rendezvous & Docking); Ground Processing Operations; Mission Operations; etc.

Responsibility: Types of Facilities

- Neutral Buoyancy Tanks; Human Factors Research Laboratories (including Virtual Reality or Flight Simulators); Radiation Effects and Protection Testing; Life Support Testbeds; etc.
- Systems-Level testing facilities associated with in-space or ground operations, etc.

General Comments

- This working group will be responsible for integrating program facility needs in the area of human & machine operations related R&D and evaluating the appropriate facilities to meet those needs.
- This working group will be responsible for identifying commonality or duplications in R&D needs or facilities between the technical working groups and making recommendations to the R&S WG.

**HUMAN AND MACHINE OPERATIONS WORKING GROUP
CATEGORY 1A RECOMMENDATIONS**

HUMAN AND MACHINE OPERATIONS CATEGORY 1A FACILITY INDEX

We have reviewed the Space R&D facilities available for use by National programs. Most of our attention was placed on Government facilities. The one area where action should be taken is recommended:

- ACCELERATE HUMAN-RATED LIFE SUPPORT TEST FACILITY CONSTRUCTION
OF FACILITY PROJECT (NASA)**

HUMAN AND MACHINE OPERATIONS

CATEGORY 1A FACILITY INDEX

FACILITY TITLE	LOCATION
Human Rated Test Facility	Johnson Space Center

ACCELERATE HUMAN-RATED LIFE SUPPORT TEST FACILITY (JSC BLDG. 241) CONSTRUCTION OF FACILITY (CoF) PROJECT (NASA)

The Human-Rated Life Support Test Facility is a ground-based test bed being developed at NASA JSC to permit the long-term full-scale evaluation of integrated regenerative life support systems technologies, including biological and physical/chemical elements, with humans. This facility is to provide NASA invaluable world-class capability for demonstrating the feasibility of regenerative life support technology for accommodating future extended duration human space missions. A multi-year CoF project to construct five sealed test chambers and surrounding climate-controlled structure is in progress, and the initial phase (2 chambers) is scheduled for completion in January 1994. However, as a result of restricted CoF budgets, completion of final construction will be deferred until FY99. As a result, final chamber outfitting necessary for full test capability at ambient pressure will be delayed until post 2000.

The Human-Rated Life Support Test Facility supports the presently defined 30-year civilian government space mission model requirements. This facility will provide (A) NASA much needed early ground-level full mission (> 1 yr.) demonstration of regenerative life support systems technology and (B) extended regenerative life support operational performance and human factors requirements experience.

Costs to complete the Human-Rated Life Support Test Facility CoF project will be \$2M. As stated above, the project will result in 5 sealed test chambers, integrated in a climate-controlled building. Programmatic funds will be used to outfit the facility with the necessary life support systems. Accelerated funding for this project would permit earlier operational capability and enhanced programmatic support in a critical enabling technology area.

RECOMMENDATION: Accelerate completion of the Human-Rated Life Support Test Facility.

ACCELERATE HUMAN-RATED LIFE SUPPORT TEST FACILITY (JSC BLDG. 241) CONSTRUCTION OF FACILITY (CoF) PROJECT (NASA)

DESCRIPTION: The Human-Rated Life Support Test Facility is a ground-based test bed being developed at JSC to permit the long-term full-scale evaluation of integrated regenerative life support systems technologies, including biological and physical/chemical elements, with humans. This facility is to provide NASA an invaluable capability for demonstrating the feasibility of regenerative life support technology for accommodating future extended duration human space missions. A multi-year CoF project is in progress, and the initial phase is scheduled for completion in January 1994. However, as a result of restricted CoF budgets, completion of final construction will be deferred until FY99 to permit full test capability at ambient pressure. Implementation of the recommendation would provide NASA earlier test capability (FY97) in a critical, enabling technology area.

PAYOFF POTENTIAL:

- Supports 30-year civilian government space mission model requirements
 - Space exploration and development/space technology
- Provides NASA early ground-level full mission demonstration of regenerative life support systems technology
- Provides NASA extended life support operational performance and human factors requirements experience

COST SUMMARY:	Implementation Cost	\$2M
	Annual Savings Or Cost	N/A

PROS:

- Provides NASA with much needed human-rated life support systems integration research facility earlier (FY97 vice FY99)
- Permits early identification of life support systems and human factors technology needs

CONS:

- Limited CoF budget

STEPS TO MAKE IT HAPPEN:

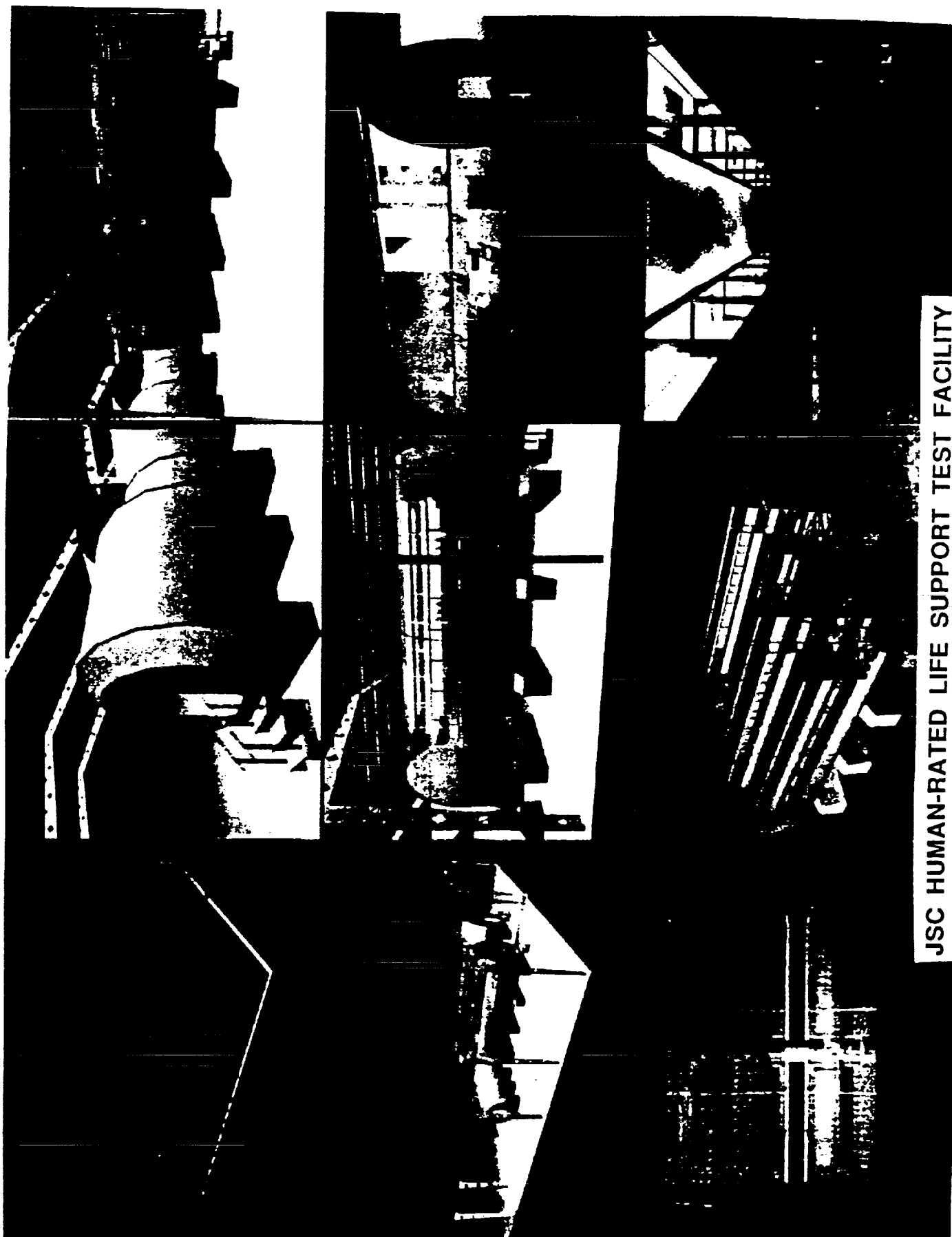
- NASA reassess annual CoF priorities and program additional CoF funds to JSC Bldg. 241 in FY95 and FY96.

TASK GROUP RECOMMENDATION: Accelerate completion of the Human-Rated Life Support Test Facility.

DATE: 12/22/93

REV:

CAT: 2



HUMAN AND MACHINE OPERATIONS WORKING GROUP CATEGORY 1B RECOMMENDATIONS

HUMAN AND MACHINE OPERATIONS CATEGORY 1B FACILITY INDEX

We have identified and reviewed human and machine operations facilities associated with space research and development utilizing the National Facilities Study inventory. Our analysis of the mission model requirements and our review of the facilities indicate that the current and planned status for the facilities on this list are appropriate.

These facilities are listed on the following pages.

HUMAN AND MACHINE OPERATIONS

CATEGORY 1B FACILITY INDEX

FACILITY TITLE	LOCATION
20G Centrifuge	Ames Research Center
Advanced Display and Spatial Perception Lab	Ames Research Center
Advisor Management/Part Task Development Lab	Ames Research Center
Auditory Display and Perceptions/Cognition Lab	Ames Research Center
Automation Sciences Research Facility	Ames Research Center
Bed Rest Facility	Ames Research Center
Biomedical Research Facility, Bldg 261	Ames Research Center
BioSciences Laboratory, N-236	Ames Research Center
Crew Human Factors Analysis Laboratory	Ames Research Center
Fatigue Countermeasures Research Lab	Ames Research Center
Flight Deck Simulator Data Analysis Laboratory	Ames Research Center
Human Powered Centrifuge	Ames Research Center
Life Sciences Research Facility, N-239, 239A, 240	Ames Research Center
Rotorcraft Human Factors Simulation Laboratory	Ames Research Center
Vestibular Research Facility, N-242	Ames Research Center
Vision Laboratory	Ames Research Center
6 Mode Vibration Test Facility	Armstrong Laboratory
Advanced Spatial Disorientation Demonstrator	Armstrong Laboratory
Aircrew Evaluation Sustained Ops Performance (AESOP)	Armstrong Laboratory
Armstrong Laboratory Centrifuge	Armstrong Laboratory
Bldg 160, 9 Research Hypobaric Chambers	Armstrong Laboratory
Davis Hyperbaric Laboratory	Armstrong Laboratory

HUMAN AND MACHINE OPERATIONS

CATEGORY 1B FACILITY INDEX (continued)

FACILITY TITLE	LOCATION
Dynamic Environment Simulator (Human Centrifuge)	Armstrong Laboratory
Exerfluge - Exercycle/Short Radius Centrifuge	Armstrong Laboratory
Horizontal Decelerator	Armstrong Laboratory
Horizontal Impulse Simulator	Armstrong Laboratory
Unholtz-Dickie Vibration Test Facility	Armstrong Laboratory
Vertical Decelerator Tower	Armstrong Laboratory
Vertical Impact Device	Armstrong Laboratory
Vertical Impulse Accelerator	Armstrong Laboratory
Human-Rated Altitude Chamber	Duke University
On-Site Hyperbaric Chamber	Duke University
Robotics Laboratory	Goddard Space Flight Center
Computer Vision Lab.	Jet Propulsion Lab
Robotic Vehicle Lab	Jet Propulsion Lab
Stieler Laboratory	Jet Propulsion Lab
Anthropometry and Biomechanics Laboratory	Johnson Space Center
Bioengineering and Test Support Facility - Bldg 36	Johnson Space Center
Crew Systems Lab Chambers - Bldg 7	Johnson Space Center
EMU Development and Test Support Lab	Johnson Space Center
Graphics Analysis Facility	Johnson Space Center
Human-Computer Interaction Laboratory	Johnson Space Center
Laboratory Support Facility - Bldg 34	Johnson Space Center
Life Sciences Laboratory - Bldg 37	Johnson Space Center

HUMAN AND MACHINE OPERATIONS

CATEGORY 1B FACILITY INDEX (continued)

FACILITY TITLE	LOCATION
On-Site Hyperbaric Chamber	Johnson Space Center
Remote Operator Interaction Laboratory	Johnson Space Center
Robotics Application Development Laboratory	Johnson Space Center
Robotics Systems Evaluation Laboratory	Johnson Space Center
Shuttle Environmental Test Article	Johnson Space Center
Space Env Sim Lab Chambers, Bldg 32	Johnson Space Center
Space Env Sim Lab Chambers, Bldg 33	Johnson Space Center
Space Systems Automated Integration & Assembly Fac	Johnson Space Center
Systems Automated Integration and Assembly Facility	Johnson Space Center
Systems Integration Facility	Johnson Space Center
Automated Structures Assembly Lab	Langley Research Center
Intelligent Sys Res Lab/Hydraulic Manipulator Testbed	Langley Research Center
Intravehicular Automation and Robotics Lab	Langley Research Center
6 Degree of Freedom Berthing/Docking System Simulator	Marshall Space Flight Center
Analytical Chem and Microbial Lab, Bldg. 4612	Marshall Space Flight Center
Flight Robotics Facility	Marshall Space Flight Center
Flight Robotics Facility	Marshall Space Flight Center
Laboratory for Structural Biology	Marshall Space Flight Center
Productivity Enhancement Complex (PEC)	Marshall Space Flight Center
Space Operations Simulator	Martin Marietta
Dynamic Flight Simulator	Naval Air Warfare Center - Warminster
Ejection Seat Tower & Vertical Decelerator	Naval Air Warfare Center - Warminster

HUMAN AND MACHINE OPERATIONS

CATEGORY 1B FACILITY INDEX (continued)

FACILITY TITLE	LOCATION
Horizontal Accelerator	Naval Air Warfare Center - Warminster
Horizontal Accelerator	Naval Biodynamics Laboratory
SIM III/Coriolis Acceleration Platform	Naval AeroMedical Research Lab
Vertical Accelerator	Naval Biodynamics Laboratory
Altitude Chambers	US Army Res Inst of Env Medicine
Human Psychology Lab	US Army Res Inst of Env Medicine
Pikes Peak Lab	US Army Res Inst of Env Medicine

HYPERGRAVITY FACILITIES (DOD/NASA)

We have reviewed the attached list of Hypergravity Facilities and feel that they are required to meet the mission model both now and in the foreseeable future. The DoD facilities' primary missions are non-space related. The requirement for these DoD facilities is reviewed annually under Project Reliance. We have not addressed the issues of standard maintenance or improvements and modernization (I&M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements.

This group sees no advantages for consolidations or closures.

Ames Research Center:

Human Powered Centrifuge
20G Centrifuge

Armstrong Laboratory:

Horizontal Impulse Simulator
Horizontal Decelerator
Vertical Decelerator Tower
Vertical Impact Device
6 Mode Vibration Test Facility
Vertical Impulse Accelerator
Unholtz-Dickie Vibration Test Facility
Armstrong Laboratory Centrifuge
Exerfuge - Exercycle/Short Radius Centrifuge
Dynamic Environment Simulator (Human Centrifuge)
Space Operations Simulator
Dynamic Flight Simulator
Horizontal Accelerator
Ejection Seat Tower & Vertical Decelerator
Horizontal Accelerator
Vertical Accelerator

Martin Marietta:

Naval Air Warfare Center - Warminster:

Naval Biodynamics Laboratory:

HYPOGRAVITY FACILITIES (DOD/NASA)

We have reviewed the following Hypogravity Facility and feel that it is required to meet the mission model both now and in the foreseeable future. We have not addressed the issues of standard maintenance or improvements and modernization (I&M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements.

This group sees no advantages for consolidations or closures.

Ames Research Center:

Bed Rest Facility

HYPO/HYPERBARIC FACILITIES (DOD/NASA)

We have reviewed the attached list of Hyper/Hypobaric Facilities and feel that they are required to meet the mission model both now and in the foreseeable future. The DoD facilities' primary missions are non-space related. The requirement for these DoD facilities is reviewed annually under Project Reliance. We have not addressed the issues of standard maintenance or improvements and modernization (I&M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements.

This group sees no advantages for consolidations or closures.

Armstrong Laboratory:

Davis Hyperbaric Laboratory
Building 160, 9 Research Hypobaric Chambers

Duke University:

Human-Rated Altitude Chamber

Johnson Space Center:

On-Site Hyperbaric Chamber
Space Env Simulation Laboratory Chambers, Bldg 32
Space Env Simulation Laboratory Chambers, Bldg 33
Crew Systems Laboratory Chambers - Bldg 7

US Army Res Inst of Env Medicine:

On-Site Hyperbaric Chamber
Altitude Chambers
Pikes Peak Lab

INERTIAL MANAGEMENT FACILITIES

(DOD/NASA)

We have reviewed the attached list of Inertial Management Facilities and feel that they are required to meet the mission model both now and in the foreseeable future. The FRL and the 6 Degree-of-Freedom Docking System Simulator are "magnet" facilities. We have not addressed the issues of standard maintenance or improvements and modernization (I&M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements.

This group sees no advantages for consolidations or closures.

Johnson Space Center:

**Systems Automated Integration and Assembly
Facility (SSAIF)**

**6 Degree-of-Freedom Berthing/Docking System Simulator
Flight Robotics Laboratory (FRL)**

Marshall Space Flight Center:

LIFE SUPPORT & EVA FACILITIES (DOD/NASA)

We have reviewed the attached list of Life Support & EVA Facilities and feel that they are required to meet the mission model both now and in the foreseeable future. The DoD facility's primary mission is non-space related. The requirement for this DoD facility is reviewed annually under Project Reliance. We have not addressed the issues of standard maintenance or improvements and modernization (I&M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements.

This group sees no advantages for consolidations or closures.

Ames Research Center:

Johnson Space Center:

BioSciences Laboratory, N-236
Bioengineering and Test Support Facility - Bldg 36
EMU Development and Test Support Lab
Shuttle Environmental Test Article
Life Sciences Laboratory - Bldg 37
Laboratory Support Facility - Bldg 34
Analytical Chem and Microbial Lab, Bldg. 4612
Laboratory for Structural Biology
Human Psychology Lab

Marshall Space Flight Center:

US Army Res Inst of Env Medicine:

SPATIAL ORIENTATION FACILITIES

(DOD/NASA)

We have reviewed the attached list of Spatial Orientation Facilities and feel that they are required to meet the mission model both now and in the foreseeable future. The DoD facilities' primary mission is non-space related. The requirement for these DoD facilities is reviewed annually under Project Reliance. We have not addressed the issues of standard maintenance or improvements and modernization (I&M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements.

This group sees no advantages for consolidations or closures.

Ames Research Center:
Armstrong Laboratory:
Naval AeroMedical Research Lab:

Vestibular Research Facility, N-242
Advanced Spatial Disorientation Demonstrator
SIM III/Coriolis Acceleration Platform

ROBOTICS FACILITIES (DOD/NASA)

We have reviewed the attached list of Robotics Facilities and feel that they are required to meet the mission model both now and in the foreseeable future. The asterisked (*) facilities are national resources and the others are program/mission specific laboratories. The SIF at JSC supports robotics operations while the FRL at MSFC provides high quality robotics experimental capability to government and commercial research organizations. We havenot addressed the issues of standard maintenance or improvements and modernization (I&M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements.

This group sees no advantages for consolidations or closures.

Goddard Space Flight Center:
Jet Propulsion Lab:

Robotics Laboratory
Computer Vision Lab
Robotic Vehicle Lab
Steler Laboratory

Johnson Space Center:

Systems Integration Facility (SIF)*

Kennedy Space Center:
Langley Research Center:

Robotics Systems Evaluation Laboratory
Robotics Application Development Laboratory
Intelligent Sys Res Lab/Hydrau Manipulator Testbed
Intravehicular Automation and Robotics Lab
Automated Structures Assembly Lab
Productivity Enhancement Complex (PEC)
Flight Robotics Facility (FRL)*

Marshall Space Flight Center:

HUMAN-MACHINE INTERFACE FACILITIES (DOD/NASA)

We have reviewed the attached list of Human-Machine Interface Facilities and feel that they are required to meet the mission model both now and in the foreseeable future. The DoD facility's primary mission is non-space related. The requirement for this DoD facility is reviewed annually under Project Reliance. We have not addressed the issues of standard maintenance or improvements and modernization (I&M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements.

This group sees no advantages for consolidations or closures.

Ames Research Center:

Automation Sciences Research Facility
Advanced Displays and Spatial Perception Lab
Advisor Management/Part Task Development Lab
Auditory Display and Perceptions/ Cognition Lab
Crew Human Factors Analysis Laboratory
Fatigue Countermeasures Research Lab
Flight Deck Simulator Data Analysis Laboratory
Rotorcraft Human Factors Simulation Laboratory
Vision Laboratory
Aircrew Evaluation Sustained Ops Performance (AESOP)
Space Systems Automated Integration & Assembly Facility
Anthropometry and Biomechanics Laboratory
Human-Computer Interaction Laboratory
Graphics Analysis Facility
Remote Operator Interaction Laboratory

Armstrong Laboratory:
Johnson Space Center:

HUMAN AND MACHINE OPERATIONS WORKING GROUP CATEGORY 2 RECOMMENDATIONS

HUMAN AND MACHINE OPERATIONS CATEGORY 2 FACILITY INDEX

We have reviewed the Space R&D facilities available for use in acceleration, food/crop growth and hypobarics and have come to the conclusion that further study is necessary to determine what specific facilities are necessary to support present and future research and development requirements. We have not been able to discuss, in the depth necessary to make a final recommendation, such issues as cost to complete, cost to operate, availability, and fair and reasonable user fees.

These are the recommendations of the working group.

- **DEVELOP A PLAN TO REPLACE EXISTING ACCELERATION FACILITIES WITH
AN ADVANCED MOTION EFFECTS R&D CENTER BY 2010 (NASA/DOD)**
- **REVIEW CURRENT CROP GROWTH RESEARCH FACILITIES
FOR POTENTIAL CONSOLIDATION (NASA)**
- **REVIEW PLANNED HYPOBARIC HUMAN-RATED CHAMBER CAPABILITIES
SUPPORTING ADVANCED LIFE SUPPORT SYSTEMS DEVELOPMENT
FOR POTENTIAL CONSOLIDATION (NASA)**

HUMAN AND MACHINE OPERATIONS**CATEGORY 2 FACILITY INDEX**

FACILITY TITLE	LOCATION
Acceleration Research Facility	
Controlled Environmental Research Chamber	Ames Research Center
Crop Growth Facility	Ames Research Center
Food Systems Engineering Facility	Johnson Space Center
Crop Growth Facility	Kennedy Space Center

DEVELOP A PLAN TO REPLACE EXISTING ACCELERATION FACILITIES WITH AN ADVANCED MOTION EFFECTS R&D CENTER BY 2010 (NASA/DOD)

Most of the existing facilities devoted to the study of the effects of acceleration on humans were built in the late 50s or early 60s. Many are approaching an age at which the cost of maintenance and repair of these facilities will make continued operations economically impractical. The need for continued acceleration research for both space and aero applications is quite obvious, however there is a need for new facilities if we are to progress into new areas of advanced acceleration R&D.

Continued research using conventional centrifuges will be required to develop crew protective equipment, mostly for the high performance aero community although some of this equipment could spin-off for manned space operations, as in the development of advanced G protective devices to protect flight crew during the reentry and landing phases of future missions. At present there are four operational conventional centrifuges in operation in the U.S. The most powerful and complex machine is operated by the Navy at Warminster PA. This is also the oldest of the U.S. centrifuge facilities. The Air Force operates two human rated centrifuges, one at Wright Patterson AFB and the other at Brooks AFB. The machine at Wright Patterson is used primarily for the study of human performance under G while the one at Brooks AFB does research on the effects of G on human physiology and develops equipment for crew G protection. NASA operates a human rated centrifuge at Ames involved primarily in vestibular and disorientation effects.

Continued acceleration research using Short Radius (<3m) Centrifuges (SRC) will be required to support all future, long term man-in-space missions to provide periodic exposure of astronauts to artificial gravity as a means of ameliorating the effects of Space Adaptation Syndrome (SAS). Regular exercise in long-duration space flights has been shown to be of some benefit in reducing the cardiovascular and musculo-skeletal deterioration caused by long exposure to a micro-gravity environment. The use of a human-powered centrifuge in space flights could simultaneously provide both of these benefits. A new human-powered SRC is being brought into operation at Ames and one is being considered at Brooks AFB.

Extremely high G onset facilities, referred to as Impact Acceleration Facilities (IAF), are also involved in acceleration research. Research using IAF devices will be required in the development of crew escape systems and crash testing. Ten IAF devices are currently in operation in the DoD and an unknown number may be in use by other agencies such as DoT, FAA, etc.

There is no device, at present, capable of examining onset ranges between that available from rocket sleds or IAFs and conventional centrifuges. Also no existing centrifuge has a sufficient radius to avoid artifacts created by coriolis and linear acceleration effects. An advanced type of very large radius centrifuge using electro-magnetic suspension and propulsion has been studied by the AF. Such a facility could provide complex, very high onset G profiles without the artifact of existing centrifuges but would be very expensive (\$150 to 200 M) to build and would have some technical risk in development.

A committee should be appointed by the NASA AA for Advanced Concepts (Code C) and the DDR&E to study the designation of a single acceleration R&D center and building any new acceleration R&D facilities at this location. Acquisition of new or significantly upgraded acceleration R&D facilities should be delayed pending the results of the study.

DEVELOP A PLAN TO REPLACE EXISTING ACCELERATION FACILITIES WITH AN ADVANCED MOTION EFFECTS R&D CENTER BY 2010 (NASA/DOD)

DESCRIPTION: The need for continued and future R&D in flight motion effects is inherent in both high performance aircraft and extended manned space missions. This research will include the physiologic and performance effects of high onset and sustained high G, spatial disorientation and extended exposure to microgravity. Most present hypergravity R&D devices are very old (circa 1960s). As continued operation of these devices becomes economically impractical, they would be phased out and replaced by a national, world class, R&D center, built post 2010, for the study of all flight motion effects. This center would have a full range of acceleration and motion effects facilities including conventional, large and short radius centrifuges, impact acceleration facilities, and spatial disorientation devices.

PAYOFF POTENTIAL: Consolidation of flight motion / hypergravity R&D will enhance research because of the capabilities of new facilities and through the interaction of scientists and engineers involved in motion effects and hypergravity research.

COST SUMMARY: TBD

PROS:

- Improved research, enhancing performance in all aspects of aero and space operations.
- Attract world class scientists.

CONS:

- Very high cost. (>\$200 M)

STEPS TO MAKE IT HAPPEN: A national study should be performed by NASA, DOD, DOT, etc., including detailed costs / benefits, to establish practicality / desirability of consolidation to validate requirements and determine actual savings potential.

TASK GROUP RECOMMENDATION: NASA AA for Advanced Concepts and Technology (Code C) and DDR&E should establish a team for a one year study of future acceleration plans and requirements and feasibility of consolidation. Study should identify and incorporate all potential user agencies. Requirements or plans for any new or significantly upgraded acceleration facilities should be reviewed by this group. This study should include Project Reliance and any consolidations of the BRAC which could effect centers now involved in acceleration research.

DATE: 1/18/94

REV:

CAT: 2

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REVIEW CURRENT CROP GROWTH RESEARCH FACILITIES FOR POTENTIAL CONSOLIDATION (NASA)

DESCRIPTION: Currently, NASA has plant research facilities at 3 different field centers: ARC (Crop Growth Research Facility), JSC (Regenerative Life Support Systems Laboratory), and KSC (Crop Growth Research Laboratory, Bldg. 239). ARC performs basic laboratory-scale plant production optimization research and KSC performs large-scale plant growth, food processing and biomass processing research. JSC is responsible for full-scale plant growth, the integration of plants with physical chemical life support elements, and integrated systems evaluations, with and without humans. Although each Center is involved in complementary research, the recommendation to consolidate/co-locate the research facilities would appear to be more efficient and cost effective.

PAYOFF POTENTIAL:

- Enhance technology program efficiency
- Synergism of basic research co-located with applications & systems integration

COST SUMMARY:	Implementation Cost	TBD
	Annual Savings Or Cost	TBD

PROS:

- Centralize technology efforts
- Enhance systems integration
- Cost savings: 1 facility, not 3

CONS:

- Requires relocation of scientists/engineers
- Costs of closing or moving facilities

STEPS TO MAKE IT HAPPEN:

- NASA perform cost impact analysis
- NASA re-define roles and missions; phase out ongoing activities accordingly
- Relocate appropriate crop growth research facilities

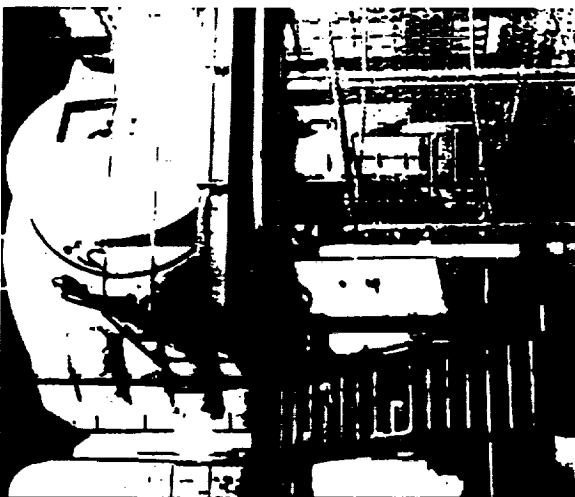
TASK GROUP RECOMMENDATION: NASA to investigate effectiveness of consolidation

DATE: 12/22/93

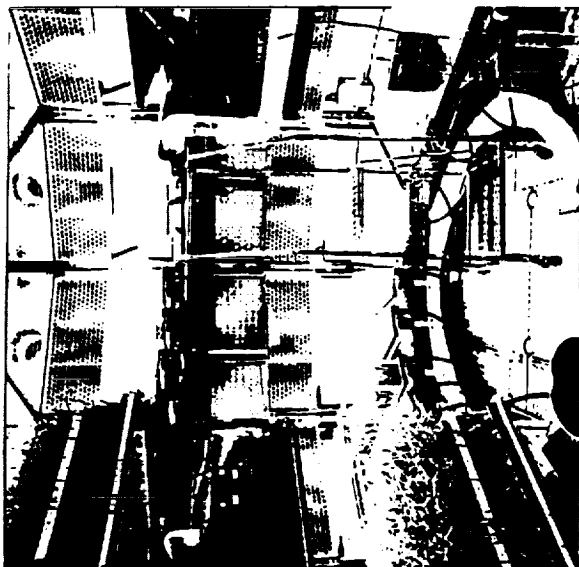
REV:

CAT: 2

KSC BIOMASS PRODUCTION CHAMBER



EXTERIOR

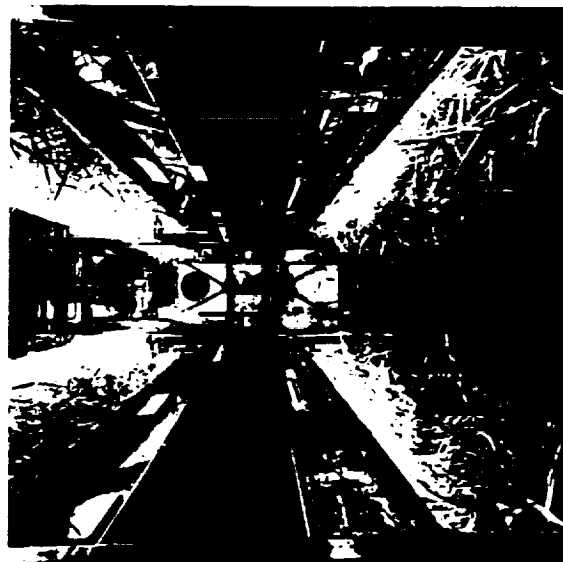


INTERIOR

JSC REGENERATIVE LIFE SUPPORT TEST BEDS



AMBIENT PRESSURE GROWTH CHAMBER



VARIABLE PRESSURE GROWTH CHAMBER

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REVIEW PLANNED HYPOBARIC HUMAN-RATED CHAMBER CAPABILITIES SUPPORTING ADVANCED LIFE SUPPORT SYSTEMS DEVELOPMENT FOR POTENTIAL CONSOLIDATION (NASA)

Currently the NASA Ames Research Center (ARC) and the Johnson Space Center (JSC) have responsibilities for advanced life support systems development. JSC is the NASA focus for the development of advanced life support systems and ARC is responsible for research devoted to new, innovative concepts. The hypobaric Controlled Environment Research Chamber (CERC) at ARC is undergoing an upgrade that includes human-rating to provide test support for advanced life support systems development. This planned ARC capability appears to be a duplication of existing human-rated hypobaric JSC test facilities, including the 20-foot chamber Systems Integrated Research Facility (SIRF) which is being utilized and is funded by NASA Headquarters (Code U) for the development of life support systems.

Benefits resulting from consolidating human hypobaric chamber testing at JSC would include both the cost savings associated with the upgrade, operations, and maintenance of the planned ARC human-rated test facility and a clarification of ARC's role as a research center.

RECOMMENDATION: NASA investigate the need for human-rated hypobaric test chamber capability at ARC.
Consolidate human hypobaric chamber life support system development testing at JSC.

REVIEW PLANNED HYPOBARIC HUMAN-RATED CHAMBER CAPABILITIES SUPPORTING ADVANCED LIFE SUPPORT SYSTEMS DEVELOPMENT FOR POTENTIAL CONSOLIDATION (NASA)

DESCRIPTION: The hypobaric Controlled Environment Research Chamber (CERC) at the NASA Ames Research Center (ARC) is undergoing an upgrade that includes human-rating to provide test support for advanced life support systems technology development. This planned ARC capability appears to be a duplication of existing Johnson Space Center (JSC) human-rated hypobaric test facilities, including the 20-foot chamber Systems Integration Research Facility (SIRF) which is a being utilized and funded by NASA Headquarters for the development of advanced life support systems.

PAY OFF POTENTIAL: Consolidation of human-rated hypobaric chamber life support system development testing at JSC would avoid unnecessary costs and duplication of capabilities.

COST SUMMARY:

- Costs for ARC chamber human-rating upgrade, maintenance and operations: TBD
- Costs for ARC human-rated hypobaric chamber test support services (e.g., backup hyperbaric treatment facilities, medical support personnel, etc.): TBD

PROS:

- Cost savings; eliminates duplication of facilities
- Clarifies ARC role as research center and JSC as development center where human-rated chamber testing is more appropriate.

CONS: None

STEPS TO MAKE IT HAPPEN: NASA investigate need for human-rated hypobaric test chamber capability at ARC.

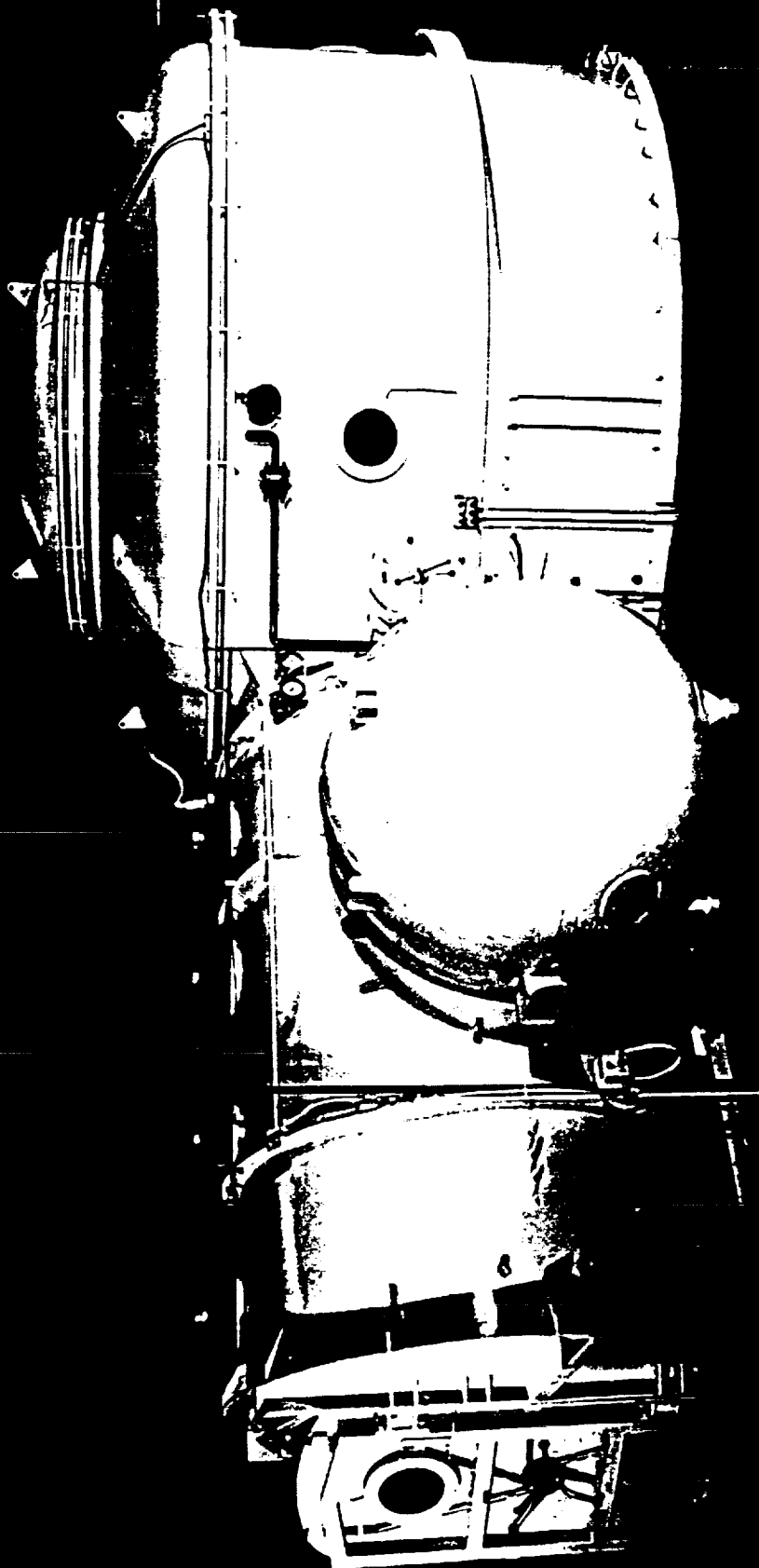
TASK GROUP RECOMMENDATION: NASA investigate the need for human-rated hypobaric test chamber capability at ARC. Consolidate human hypobaric chamber life support system development testing at JSC.

DATE: 1/10/94

REV:

CAT: 2

CONTROLLED ENVIRONMENTAL RESEARCH CHAMBER



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VALIDATE THE NEED FOR A NATIONAL SPACE RADIATION EFFECTS FACILITY

(NASA, DoD, DoE)

Since the discovery of the Van Allen radiation belts, the U.S. space program has taken measures to protect humans and hardware from the effects radiation in space, such as by adding shielding to spacecraft, developing radiation-hardened components, and by using orbits which minimize exposure to the Earth's radiation belts or other electromagnetic disturbances in space.

In 1993, the Department of Energy closed the BEVELAC facility that had been used for 30 years to: calibrate spacecraft radiation detectors, conduct radiobiological studies of exposure to protons and electrons and high-energy heavy and light ions up to the GeV per nucleon range found in space, assess radiation shielding needs for space missions, and define the impact of radiation on sensitive electronic components. The BEVELAC was the only facility in the United States capable of simulating all components of space radiation for the U.S. civil, commercial, and national security space programs (2.0 GeV per nucleon for heavy ions and 3 GeV for protons). The United States now does not have an operational facility to conduct space radiation effects research.

Accelerator facilities exist in the United States, Germany, France and Russia that could fill this void. However, each of these facilities has some deficiency that makes it not fully capable to meet the requirements of the Mars excursion.

TASK GROUP RECOMMENDATION: NASA, DoD, and DoE to validate the need for an experimental facility in the United States to conduct a national radiation effects research program.

VALIDATE THE NEED FOR A NATIONAL SPACE RADIATION EFFECTS FACILITY (NASA, DoD, DoE)

DESCRIPTION: In 1993, the Department of Energy closed the BEVELAC facility that had been used for 30 years to: calibrate spacecraft radiation detectors, conduct radiobiological studies of exposure to protons and electrons and high-energy heavy and light ions up to the GeV per nucleon range found in space, assess radiation shielding needs for space missions, and define the impact of radiation on sensitive electronic components. The BEVELAC was the only facility in the United States capable of simulating all components of space radiation for the U.S. civil, commercial, and national security space programs (2.0 GeV per nucleon for heavy ions and 3 GeV for protons). The United States now does not have an operational facility to conduct space radiation effects research.

PAYOFF POTENTIAL:

- Provide the capability to assess space radiation effects for the Mars mission excursion.

COST SUMMARY:	Implementation Cost	TBD
	Annual Cost	TBD

PROS:

- Provide an additional test and assessment capability for the U.S.

CONS:

- Costs of developing and operating such a facility

STEPS TO MAKE IT HAPPEN:

- NASA, DoD, and DoE meet to determine requirements
- The three Agencies assess existing alternatives to developing a new facility
- The three Agencies make a decision as to the best alternative to meet the excursion requirements

TASK GROUP RECOMMENDATION: NASA, DoD, and DoE to validate the need for an experimental facility in the United States to conduct a national radiation effects research program.

DATE: 3/25/94

REV:

CAT: 2

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HUMAN AND MACHINE OPERATIONS WORKING GROUP CATEGORY 3 RECOMMENDATIONS

III-133

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HUMAN AND MACHINE OPERATIONS CATEGORY 3A FACILITY INDEX

An initial review of the Space R&D facilities revealed that some facilities would have low potential for cost savings. By using the evaluation criteria for Human and Machine Operations facilities, we obtained the following list of 3A facilities. These include spatial orientation and inertial management facilities.

The group sees no advantages for consolidation or closures of these facilities.

HUMAN AND MACHINE OPERATIONS

CATEGORY 3A FACILITY INDEX

FACILITY TITLE	LOCATION
Flight Instrumentation Development Laboratory	Armstrong Laboratory
Internal Medicine Branch, Bed Rest Facility	Armstrong Laboratory
Visual Orientation Laboratory (VOL)	Armstrong Laboratory
Ashton Graybiel Laboratory	Brandeis University
Precision Air Bearing Facility	Johnson Space Center
Impact Dynamics Research	Langley Research Center
Vehicle Emulator Facility	Langley Research Center
Flat Floor	Martin Marietta Astronautics
Space Operations Simulator	Martin Marietta Astronautics
Disturbance Test Facility	Massachusetts Inst of Technology

HUMAN AND MACHINE OPERATIONS CATEGORY 3B FACILITY INDEX

The Human and Machine Operations Working Group was aware of non-government facilities which are used for robotics research and development, but were not in the inventory database. Therefore, they were not evaluated with respect to the mission model due to lack of sufficient data.

These facilities are listed on the following page.

HUMAN AND MACHINE OPERATIONS

CATEGORY 3B FACILITY INDEX

FACILITY TITLE	LOCATION
Robotics Facilities	Boeing
Robotics Facilities	Carnegie Mellon University
Robotics Facilities	Erim
Robotics Facilities	Grumann
Robotics Facilities	Lockheed
Robotics Facilities	Los Alamos National Laboratory
Robotics Facilities	Martin Marietta
Robotics Facilities	Massachusetts Inst of Technology
Robotics Facilities	McDonnell Douglas
Robotics Facilities	NIST
Robotics Facilities	Oak Ridge National Laboratory
Robotics Facilities	Oceaneering
Robotics Facilities	Rockwell
Robotics Facilities	Sandia National Laboratory
Robotics Facilities	SRI International
Robotics Facilities	Stanford University
Robotics Facilities	University of Maryland
Robotics Facilities	University of Michigan
Robotics Facilities	University of Texas
Robotics Facilities	Wester Space and Marine

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**INFORMATION AND COMMUNICATIONS
WORKING GROUP**

FACILITY FINDINGS

SPACE R&D TASK GROUP

Information & Communications Working Group

Responsibility: Technical Areas of Responsibility

- Focal Plane Sensors, Optical Systems, Cryogenics and Coolers, Remote Sensing Systems, Antennas, Data Systems (Ground and Space); Microelectronics; Micro- and Milli- meterwave Electronics; Photonics; RF and Optical Communications Systems; Software (generic); Instrument Pointing and Tracking; etc.

Responsibility: Types of Facilities

- Antenna Test Ranges; Cooler Testbeds; etc.
- Systems-Level Testing of Integrated Communications Systems.

General Comments

- This working group will be responsible for integrating program facility needs in the area of information & communications related R&D and evaluating the appropriate facilities to meet those needs.
- This working group will be responsible for identifying commonality or duplications in R&D needs or facilities between the technical working groups and making recommendations to the R&S WG.

**INFORMATION SYSTEMS AND COMMUNICATIONS
WORKING GROUP**

CATEGORY 1A RECOMMENDATIONS

INFORMATION AND COMMUNICATIONS WORKING GROUP

We have reviewed the space R & D facilities available for use by national programs and identified those with significant capability for information and communications R & D. Most of our attention was placed on government facilities although industry owned facilities were considered as alternative capability to government facilities. Two areas where action should be taken are recommended:

- o The JPL Mirror Refurbishment Facility should be shut down when the present Cassini related work is completed.
- o The construction and outfitting of the "DECADE" nuclear weapons effect test facility at AEDC should be completed on schedule.
- o A procedure should be established through the Space Technology Interdependency Group (STIG) that sponsors of any proposed new or upgraded antenna facilities must pass.

INFORMATION & COMMUNICATIONS WORKING GROUP

CATEGORY 1A FACILITY INDEX

FACILITY	LOCATION
Mirror Refurbishment Building	JET PROPULSION LABORATORY, CA
DECADE Test Facility	ARNOLD ENGINEERING DEVELOPMENT CENTER, TN
Antenna Laboratories	BOEING, WA
Boardman Remote Radar Cross Section Range	BOEING, OR
Compact Range	BOEING, WA
Millimeter-Wave RCS Measurement Laboratory	BOEING, WA
EML 1, 2 Labs Twin Creeks Antenna Range	BOEING, WA
Kent Space Center Radar Cross Section Laboratories	BOEING, WA
Microwave Antenna Range (N39)	BOEING, KS
Large Anechoic Chamber	COMSAT CORPORATION, MD
Outdoor Antenna Test Range	COMSAT CORPORATION, MD
Small Anechoic Chamber	COMSAT CORPORATION, MD
A1 Anechoic Chamber	HUGHES, CA
A2 Anechoic Test Chamber	HUGHES, CA
40' Microwave Anechoic Chamber	JET PROPULSION LABORATORY, CA
60' Microwave Anechoic Chamber	JET PROPULSION LABORATORY, CA
East Antenna Range	JET PROPULSION LABORATORY, CA
West Antenna Range	JET PROPULSION LABORATORY, CA
Microwave Anechoic Chambers	JET PROPULSION LABORATORY, CA
256 East Antenna Range	JET PROPULSION LABORATORY, CA
1200 Antenna Range	JET PROPULSION LABORATORY, CA
3,000 Feet Antenna Range	JET PROPULSION LABORATORY, CA
Anechoic Chamber	JOHNSON SPACE CENTER, TX
Tracking Techniques Laboratory	JOHNSON SPACE CENTER, TX
Experimental Test Range	LANGLEY RESEARCH CENTER, VA

Compact Range Pilot Facility	LANGLEY RESEARCH CENTER, VA
Low Frequency Antenna Test Facility	LANGLEY RESEARCH CENTER, VA
Microwave Systems Laboratory, Near Field Laboratory	LEWIS RESEARCH CENTER, OH
Antenna And Anechoic Facility, B/076 A	LOCKHEED, CA
Antenna And Anechoic Facility, B/076 B	LOCKHEED, CA
Antenna Pattern Measurements Laboratory	LOCKHEED, GA
Radar Cross Section (RCS) Laboratory	LOCKHEED, GA
Anechoic Chamber, Building 213	LOCKHEED, TX
1/2 Mile Antenna Test Range	MARSHALL SPACE FLIGHT CENTER, AL
400-Ft. Antenna Test Range	MARSHALL SPACE FLIGHT CENTER, AL
Anechoic Chamber	MARSHALL SPACE FLIGHT CENTER, AL
Large Antenna Test Facility	PHILLIPS LAB / KIRTLAND AFB, CA
Radiometric Chamber	ROCKWELL, CA
RF Anechoic Test Facility	ROCKWELL, CA
Anechoic Chamber A	TRW SPACE AND ELECTRONICS GROUP, CA
Anechoic Chamber B	TRW SPACE AND ELECTRONICS GROUP, CA
VAFB, Anechoic Chamber, Bldg. 1559	VANDENBERG AIR FORCE BASE, CA

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MAINTAIN SCHEDULED SHUTDOWN OF JPL MIRROR REFURBISHMENT FACILITY (NASA/JPL)

The JPL Mirror Refurbishment Facility was established in 1992 to provide a facility to refurbish the 23 Ft. diameter mirror for a 25 Ft. Space Simulator. The 4000 square foot Butler building houses a large computer-controlled grinding and polishing machine that was used to prepare the mirror surface for replating with nickel and to grind and polish the nickel plated surface to a specified contour. Completion of the work is needed to support Cassini.

Current plans are to deactivate the facility when this job is complete and to put the mirror grinding machine in storage. Thermal Vac facilities will then be moved into the Butler building to alleviate overcrowding in Building 144 where they presently reside. Building 144 has been cited for hazardous exposure of flight hardware due to overcrowding.

MAINTAIN SCHEDULED SHUTDOWN OF JPL MIRROR REFURBISHMENT FACILITY (NASA/JPL)

DESCRIPTION: The facility was established in FY 92 to refurbish the 23 Ft. Diameter mirror for the 25 Ft. Space Simulator. The work ultimately is needed to support Cassini. Current plans are to shut down the mirror refurbishment facility when this job is complete and to store the mirror grinding machine. Thermal Vac facilities, which presently reside in a building that is overcrowded, will be relocated into the building now housing the mirror refurbishing facility.

PAYOFF POTENTIAL: Current mirror refurbishment O & M cost between 25 and 100 \$K.

COST SUMMARY:

Implementation Costs:	TBD
O & M Costs:	Less Than \$100K/Yr.
Anticipated Net Savings:	25-100 \$K/Yr.

PROS:

- Eliminate O & M cost.
- Promote safety and operational efficiency in JPL Thermal Vac test operations.

CONS:

- None

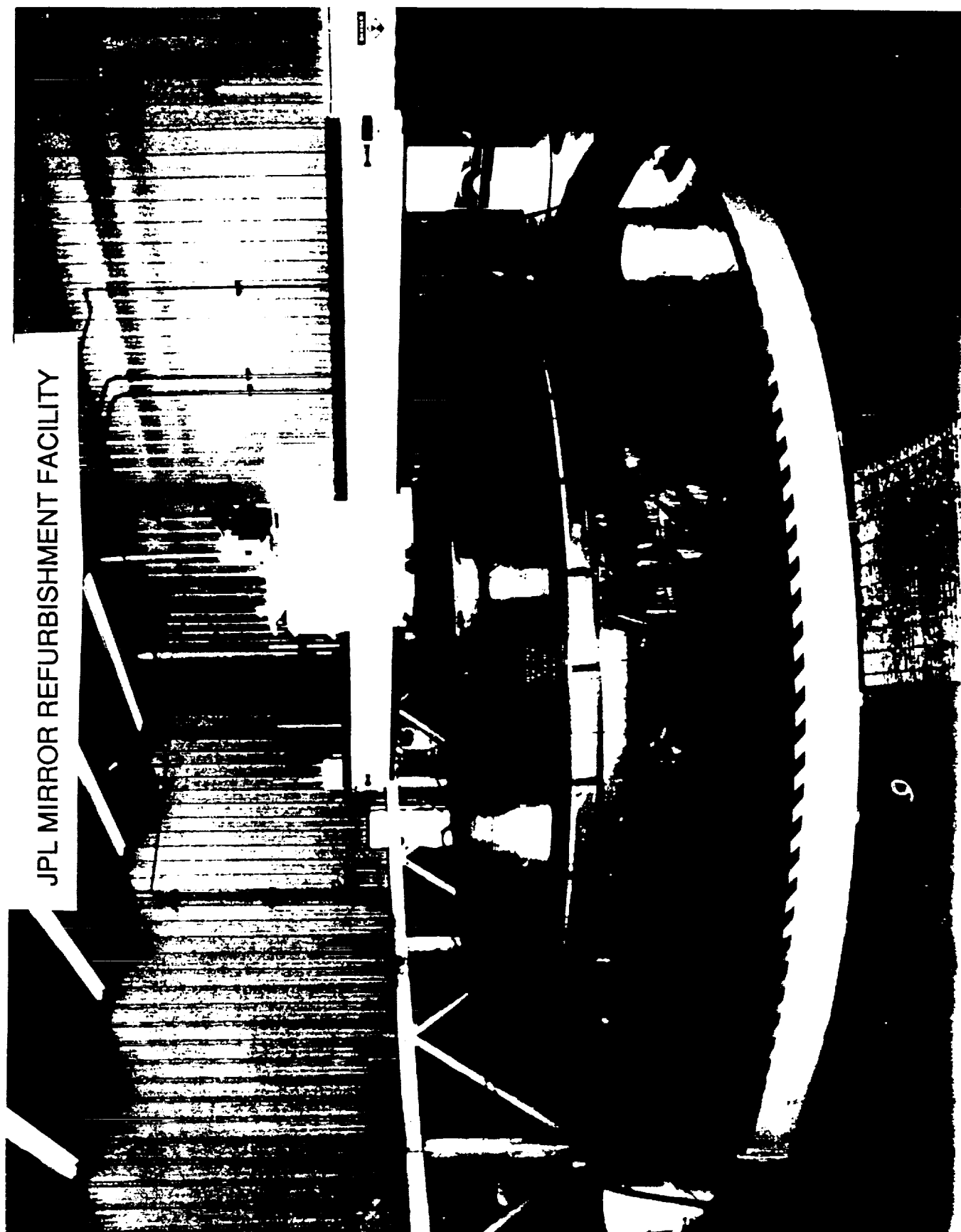
STEPS TO MAKE IT HAPPEN: JPL maintains plan to shut down the mirror grinding facility when Cassini related work is completed.

TASK GROUP RECOMMENDATION: Maintain plan to end mirror refurbishment work.

DATE: 3/18/94

REV: 3/23/94

CATEGORY 1A



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MAINTAIN SCHEDULED CONSTRUCTION AND OUTFITTING OF THE DECADE TEST FACILITY (DNA/AEDC)

The DECADE facility is a nuclear weapons effect test facility designed to permit ensemble testing of missile and satellite electronics as an alternative to underground testing (UGT). The facility is currently under construction with a projected Initial Operational Capability (IOC) in the Cy 96/97 time frame. It will be housed in a 44,000 square foot building and will consist of an inductive energy storage simulator within a radiation shielded test bay; adjoining maintenance and repair shop; a user suite consisting of offices, user setup areas, RF shielded user data acquisition screen room, and office space for administrative personnel.

When completed DECADE will be the only viable operational alternative to UGT and supports repeatable, high fidelity testing of large surface area electronic packages (up to 1 square meter) within an above ground environment. The facility will have an X Ray simulator with a dose-area product 10 times greater than any existing DOD simulator. The facility is currently under construction at a reported brick and mortar cost of 5-10 \$M and an outfitting cost of 50-100 M. The reported O&M costs are less than \$25K per year.

The global ban on nuclear testing and critical need for continuing assessment of strategic, nuclear survivable mission equipment against established JCS threat levels supports this facility design as the only viable alternative to UGT. Upon completion the facility will provide the only test capability of large surface area electronic modules/subsystems/systems for advanced space communications, surveillance, and missile designs well into the 21 st century.

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MAINTAIN SCHEDULED CONSTRUCTION AND OUTFITTING OF THE DECADE FACILITY (DNA/AEDC)

DESCRIPTION: The DECADE facility is a nuclear weapons effects test facility designed to permit ensemble testing of missile or satellite electronics as an alternative to underground testing. The facility is designed to support repeatable, high fidelity testing of JCS threat level fluence over large areas (up to 1 square meter). The facility is currently under construction with a projected IOC date in the Cy 96-97 time frame.

PAYOFF POTENTIAL: -Will provide only adequate operational alternative to underground nuclear testing for testing of large satellite and missile electronics modules.

COST SUMMARY:

- Implementation Cost: 50-100 \$M
- O & M Cost: TBD
- Anticipated Net Savings NA

PROS: -Provides only viable alternative to underground nuclear testing (UGT) of large surface area integrated electronics against JCS level threats.

CONS: -None

STEPS TO MAKE IT HAPPEN: AEDC maintains DECADE construction and outfitting schedule to IOC.

TASK GROUP RECOMMENDATION: Maintain existing plan and schedule to IOC.

DATE: 3/18/94

REV: 3/23/94

CATEGORY 1A

DECADE FACILITY



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SCREEN NEW OR UPGRADED ANTENNA TEST FACILITIES (NASA/DOD)

The NFS Data Base contains 40 antenna test facilities, in 18 different locations, with 13 institutional owners. NASA owns 17 of these facilities at 2 different research centers and 3 flight centers. The data base is believed to contain only about half of the significant U. S. government, industry, and university antenna test facilities. Many USAF facilities were not included probably because their owners did not view them as "space" facilities. No USN, USA, or university owned antenna test facilities were submitted to the data base. And a great deal of industry capability is also missing from the data base.

There is significant duplicate capability even in the 17 NASA owned antenna facilities. And, even though only 33 of 40 antenna facility submissions to the data base contained cost data, the total reported investment in antenna test facilities is at least \$639 Million and the total reported O&M cost is about \$2.3 Million. These same 33 facilities have an average reported utilization rate of 51.7 %.

Each installation can justify it's antenna test capability as necessary to meet it's programmatic commitments. And the potential O&M cost savings associated with closing a facility is generally not large enough for this working group to recommend consolidation of geographically separate activities. However these facility justifications depend entirely on present installation roles and missions. In both NASA and DOD installation roles and missions are presently undergoing review. Because of rather severe budget pressures it is likely that significant changes will result, from these reviews, in a relatively short time. So part of the over-capacity is likely to be eliminated in any case.

It is recommended that the Space Technology Interdependency Group (STIG) establish a screening procedure which any proposed antenna facility construction or upgrades must pass. Their advocates most affirmatively demonstrate that their facility needs are unique with respect to existing national capability.

SCREEN NEW OR UPGRADED ANTENNA TEST FACILITIES (NASA/DOD)

DESCRIPTION: There are 40 antenna test facilities in the NFS data base with a substantial degree of duplication in capability. Yet all appear to be required to meet institutional commitments. Some of this excess capacity may be soon eliminated by budget driven institutional consolidations and reforms.

PAYOFF POTENTIAL: The 40 antenna test facilities in the data base represent a reported investment of about \$630 Million and a reported annual O & M cost of about \$2.3 Million. Average reported utilization rate is about 50 %. A significant fraction of this capability may therefore be unneeded.

COST SUMMARY:

-Implementation Cost:	NA
-O & M Cost:	\$2.3 Mil.
-Annual Savings:	Perhaps 1 % of the \$630 Million

PROS: -Potential Cost Savings

CONS: -None

STEPS TO MAKE IT HAPPEN: The STIG establishes a screening procedure which any proposed antenna facility construction or upgrade must pass.

TASK GROUP RECOMMENDATION: Procedural Screen

DATE: 3/18/94 REV: 3/23/94

CATEGORY 1A

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**INFORMATION SYSTEMS AND COMMUNICATIONS
WORKING GROUP**

CATEGORY 1B RECOMMENDATIONS

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INFORMATION AND COMMUNICATIONS WORKING GROUP

We have identified and reviewed information and communications facilities associated with Space Research and Development utilizing the National Facilities Study Facilities Inventory Database. Those facilities owned by private industry were considered only as providing alternate capability for government owned facilities. And government facilities which are required to fulfill the assigned role of their institutional owner were considered necessary to maintain in operation.

Our analysis of the mission model requirements, recognition of the prerogatives of private industrial facility owners, and recognition of the facility needs imposed by institutional roles within the government, and review of the facilities, indicate that the current and planned status of the facilities on this list are appropriate.

INFORMATION & COMMUNICATIONS WORKING GROUP

CATEGORY 1B FACILITY INDEX

FACILITY	LOCATION
Sensor Development Processing Laboratory	AEROJET ELECTRONICS SYSTEMS DIVISION, CA
Microelectronics Evaluation Center	AEROSPACE CORPORATION, CA
Microelectronics Evaluation Center	AEROSPACE CORPORATION, CA
C-141A Kuiper Airborne Observatory (NASA 714)	AMES RESEARCH CENTER, CA
ER-2 High Altitude Laboratory (NASA 706, 708, 709)	AMES RESEARCH CENTER, CA
Focal Plane Characterization Chamber (FPCC)	ARNOLD ENGINEERING DEVELOPMENT CENTER, TN
Direct Write Scene Generator	ARNOLD ENGINEERING DEVELOPMENT CENTER, TN
Radio Frequency Simulation System (RFSS)	BMDO, AL
Boeing Radiation Effects Laboratory	BOEING, WA
Central Signal Processing Laboratory	BOEING, WA
Electromagnetic Effects Laboratory	BOEING, WA
EO/IR Sensors Laboratory	BOEING, WA
Guidance, Navigation & Control Laboratory	BOEING, WA
Precision Optical Measurement Laboratory	BOEING, WA
Sensor Seeker Integration Laboratory	BOEING, WA
Central Dynamic Instrumentation Laboratory	BOEING, WA
Data Systems Support Laboratory	BOEING, WA
Mobile Data Systems	BOEING, WA
Sensor Seeker Simulation Laboratory	BOEING, WA
High Energy Laser Laboratory	BOEING, WA
IR Signature Laboratory	BOEING, WA
Laser Etch Laboratory	BOEING, WA
Transmission Test Laboratory	BOEING, PA
Data Processing/Ground Station Laboratory	BOEING, KS
Image Processing/Sensor Technology Laboratory	BOEING, KS

Instrumentation Development/Fabrication Laboratory	BOEING, KS
Radar Systems Laboratory	BOEING, KS
Infrared Signature Measurement Laboratory	BOEING, PA
Electromagnetic Environmental Effects Laboratory	BOEING, AL
Laser Fabrication Laboratory	BOEING, WA
Microelectronics Laboratory	BOEING, WA
Optical Element Laboratory	BOEING, WA
Opto-Electronics Characterization Laboratory	BOEING, WA
Opto-Electronics Packaging Laboratory	BOEING, WA
Opto-Electronics Subsystems Laboratory	BOEING, WA
RF Systems Laboratory	BOEING, WA
Thin Film Deposition Laboratory	BOEING, WA
Communications Laboratory Y1	BOEING, WA
Computer Image Generation Laboratories E1/E2	BOEING, WA
Video Systems Laboratory D1	BOEING, WA
Communications Laboratory	BOEING, WA
Image Analysis Laboratory	BOEING, WA
Laser Development Laboratory	BOEING, WA
Data Management Laboratory	BOEING, WA
RF Sensors Radar Development Laboratory	BOEING, WA
Electrical/Electronics Materials/Processes R&D Lab	BOEING, WA
Signature Material Laboratory	BOEING, WA
Lithography/Clean Operations Laboratory	BOEING, WA
Electronics Subsystems Integration Laboratory	BOEING, WA
Semiconductor Fabrication 1	COMSAT CORPORATION, MD
Semiconductor Fabrication 2	COMSAT CORPORATION, MD
Semiconductor Fabrication 3	COMSAT CORPORATION, MD
Semiconductor Fabrication 4	COMSAT CORPORATION, MD
Semiconductor Fabrication 5	COMSAT CORPORATION, MD
Semiconductor Fabrication 6	COMSAT CORPORATION, MD
Semiconductor Fabrication 7	COMSAT CORPORATION, MD

Subjective Evaluation Room	COMSAT CORPORATION, MD
System Simulation Laboratory	COMSAT CORPORATION, MD
Video System Laboratory	COMSAT CORPORATION, MD
Magnetic Field Component Test Facility / Bldg 303	GODDARD SPACE FLIGHT CENTER, MD
Magnetic Test Facilities Control Bldg / Bldg 304	GODDARD SPACE FLIGHT CENTER, MD
Spacecraft Magnetic Test Facility / Bldg 305	GODDARD SPACE FLIGHT CENTER, MD
Optics Laboratory	HONEYWELL, INC.-SPCE SYSTEMS DIVISION, AZ
Integrated Circuit Design Center	HONEYWELL, INC.-SPCE SYSTEMS DIVISION, FL
Radio Frequency Breakdown Facility	JET PROPULSION LABORATORY, CA
Frequency Standards Laboratory	JET PROPULSION LABORATORY, CA
JPL's Microdevices Laboratory (MDL)	JET PROPULSION LABORATORY, CA
Optical Laboratories	JET PROPULSION LABORATORY, CA
Electromagnetic Systems Laboratory	JOHNSON SPACE CENTER, TX
Communications System Analysis & Simulation Laboratory	JOHNSON SPACE CENTER, TX
Electronic Systems Test Laboratory	JOHNSON SPACE CENTER, TX
Flight Telecommunications Laboratory	JOHNSON SPACE CENTER, TX
Detector Development and Characterization Laboratory	LANGLEY RESEARCH CENTER, VA
Optics Development and Characterization Laboratory	LANGLEY RESEARCH CENTER, VA
Sensor Development Laboratory	LANGLEY RESEARCH CENTER, VA
LASER R&D Laboratory	LOCKHEED, GA
L-9 Scanning Electron Microscopy Laboratories	LOCKHEED, GA
Communications Products Center	LOCKHEED, CA
IR Detector Engineering/Manufacturing Facility	LORAL INFRARED AND IMAGING SYSTEMS, MA
Space Instruments Development Facility	LORAL INFRARED AND IMAGING SYSTEMS, MA
Monolithic Technology Laboratory	MARSHALL SPACE FLIGHT CENTER, AL
Precision Artwork Generator Facility	MARSHALL SPACE FLIGHT CENTER, AL
Precision Optical Fabrication Facility	MARSHALL SPACE FLIGHT CENTER, AL
RF (Radio Frequency) & Microwave Laboratory	MARSHALL SPACE FLIGHT CENTER, AL
Software Development & Technology Laboratory	MARSHALL SPACE FLIGHT CENTER, AL
Straylight Facility	MARSHALL SPACE FLIGHT CENTER, AL
Audio Reverberant Facility	MARSHALL SPACE FLIGHT CENTER, AL

Space Plasma Physics Laboratory	MARSHALL SPACE FLIGHT CENTER, AL
Holographic and Optical Analysis Laboratory	MARSHALL SPACE FLIGHT CENTER, AL
Continuous Wavelength Laser Laboratory (CWLL) Area, SSPL	ROCKWELL, CA
Electrodeposition Laboratory, B/0038	ROCKWELL, CA
Electronics Laboratory, B/0020	ROCKWELL, CA
Instrumentation Laboratory (SSFL), B/1324	ROCKWELL, CA
KEW Electronics Laboratory, B/0009	ROCKWELL, CA
Rocketdyne Electronics Laser Laboratory (RELL), B/0008	ROCKWELL, CA
Seal Beach, B/084 Non-Linear Optics Laboratory	ROCKWELL, CA
CTL III Laser Facility	ROCKWELL, CA
Rome Lab Communication Experimental Facility	ROME LABORATORY, NY
Rome Lab Laser Communications Facility	ROME LABORATORY, NY
Rome Lab Orbital Network Simulation Facility	ROME LABORATORY, NY
Rome Lab Photonics Center	ROME LABORATORY, NY
Rome Lab Surveillance Facility	ROME LABORATORY, NY
Electronic Test Facility	TRW SPACE AND ELECTRONICS GROUP, CA
Orbital Test Facility	TRW SPACE AND ELECTRONICS GROUP, CA
Electronics Lab, R4	TRW SPACE AND ELECTRONICS GROUP, CA
Electronics Lab, R9	TRW SPACE AND ELECTRONICS GROUP, CA
Optics Lab	TRW SPACE AND ELECTRONICS GROUP, CA
Indium Antimonide Detector Fabrication	Westinghouse Electric WEST*QUEST, MD
Microwave/Acoustic Laboratory	Westinghouse Electric WEST*QUEST, MD
GaAs Engineering Laboratory	Westinghouse Electric WEST*QUEST, MD
GaAs Fabrication Laboratory	Westinghouse Electric WEST*QUEST, MD
INSB Sensor Chip Assembly Laboratory	Westinghouse Electric WEST*QUEST, MD
VLSI Laboratory - Photolithography	Westinghouse Electric WEST*QUEST, MD
VLSI Laboratory-Deposition, Oxidation	Westinghouse Electric WEST*QUEST, MD
Mask-Making & Direct-Write Lab	Westinghouse Electric WEST*QUEST, MD

INFORMATION & COMMUNICATIONS WORKING GROUP

(NASA / DOD)

We have reviewed the attached list of government owned Information & Communication R&D facilities and feel that, together with Industry owned facilities, they are adequate to meet the mission model both now and in the foreseeable future. We have not addressed the issues of standard maintenance or improvements and modernization (I&M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements.

Based on our review and analysis of data received, this group concludes that these facilities are integral to the mission of organizations at which they are located. This group sees no advantages for consolidations and/or closures of these facilities unless there is a realignment/redefinition of the owning organization's roles and missions.

AMES:	C-141A Kuiper Airborne Observatory (NASA 714), ER-2 High Altitude Laboratory (NASA 706,708,709)
AEDC:	Focal Plane Characterization Chamber (FPCC), Direct Write Scene Generator
BMDO:	Radio Frequency Simulation System (RFSS)
GODDARD:	Magnetic Field Component Test Facility / Bldg 303, Magnetic Test Facilities Control Bldg / Bldg 304, Spacecraft Magnetic Test Facility / Bldg 305
JPL:	Radio Frequency Breakdown Facility, Frequency Standards Laboratory, JPL's Microdevices Laboratory (MDL), Optical Laboratories
JOHNSON:	Electromagnetic Systems Lab, Communications System Analysis & Sim Lab, Electronic Systems Test Lab, Flight Telecommunications Laboratory
LANGLEY:	Detector Development and Characterization Lab, Optics Development and Characterization Laboratory, Sensor Development Laboratory
MARSHALL	Monolithic Technology Laboratory, Precision Artwork Generator Facility, Precision Optical Fabrication Facility, RF & Microwave Laboratory, Software Development & Technology Laboratory, Straylight Facility, Audio Reverberant Facility, Space Plasma Physics Laboratory, Holographic and Optical Analysis Laboratory
ROME LABS:	Rome Lab Communication Experimental Facility, Rome Lab Laser Communications Facility, Rome Lab Orbital Network Simulation Facility, Rome Lab Photonics Center, Rome Lab Surveillance Facility
WALLOPS:	Magnetic Field Simulation Laboratory

INFORMATION & COMMUNICATIONS WORKING GROUP

(INDUSTRY)

We have reviewed the attached list of industry owned Information & Communication R&D facilities and feel that, together with government owned facilities, they are adequate to meet the mission model both now and in the foreseeable future. We have not addressed the issues of standard maintenance or improvements and modernization (I&M) to keep these functions on line as we expect the facility managers to ensure continued operational capability to match the mission model requirements.

Clearly this working group is in no position to pass judgement on the requirements for Industry owned facilities. It is the prerogative of the private owners to originate change/consolidate/closure recommendations. This group sees no advantages for consolidations or closures.

AEROJET:

Sensor Development Processing Laboratory

AEROSPACE:

Microelectronics Evaluation Center I and II

BOEING:

Boeing Radiation Effects Lab, Central Signal Processing Laboratory, Electromagnetic Effects Laboratory, EO/IR Sensors Laboratory, Guidance Navigation & Control Laboratory, Precision Optical Measurement Laboratory, Sensor Seeker Integration Laboratory, Central Dynamic Instrumentation Laboratory, Data Systems Support Laboratory, Mobile Data Systems, Sensor Seeker Simulation Laboratory, High Energy Laser Laboratory, IR Signature Laboratory, Laser Etch Laboratory, Transmission Test Laboratory, Data Processing/Ground Station Laboratory, Image Processing/Sensor Technology Lab, Instrumentation Development/Fabrication Lab, Radar Systems Laboratory, Infrared Signature Measurement Laboratory, Electromagnetic Environmental Effects Lab, Laser Fabrication Laboratory, Microelectronics Laboratory, Optical Element Laboratory, Opto-Electronics Characterization Laboratory, Opto-Electronics Packaging Laboratory, Opto-Electronics Subsystems Laboratory, RF Systems Laboratory, Thin Film Deposition Laboratory, Communications Laboratory Y1, Image Analysis Laboratory, Computer Image Generation Laboratories E1/E2, Video Systems Laboratory, Communications Laboratory, Laser Development Laboratory, Data Management Laboratory, RF Sensors Radar Development Laboratory, Electrical/Electronics Materials/Process R&D Lab, Signature Material Laboratory, Lithography/Clean Operations Laboratory, Electronics Subsystems Integration Laboratory

COMSAT: Semiconductor Fabrication 1, 2, 3, 4, 5, 6, 7, Subjective Evaluation Room, System Simulation Laboratory, Video System Laboratory

HONEYWELL: Optics Laboratory, Integrated Circuit Design Center

LOCKHEED: Laser R&D LAB, L-9 Scanning Electron Microscopy Labs, Communications Product Center, Anechoic Chamber, Bldg. 213

LORAL: IR Detector Engineering/Manufacturing Facility, Space Instruments Development Facility

ROCKWELL: Continuous Wavelength Laser Lab, Electrodeposition Lab, Electronics Lab, Instrumentation Lab, KEW Electronics Lab, Electronics Laser Lab, Non-Linear Optics Lab, CTL III Laser Facility

TRW: Electronic Test Facility, Orbital Test Facility, Anechoic Chamber A, Anechoic Chamber B, Electronics Lab (R4), Electronics Lab (R9), Optics Lab

WESTINGHOUSE: Indium Antimonide Detector Fabrication, Microwave/Acoustic Laboratory, GaAs Engineering Lab, GaAs Fabrication Lab, INSB Sensor Chip Assembly Lab, VLSI Lab-Photolithography, VLSI Lab-Deposition/Oxidation, Mask Making & Direct-Write Lab

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**INFORMATION SYSTEMS AND COMMUNICATIONS
WORKING GROUP**

CATEGORY 3 RECOMMENDATIONS

INFORMATION AND COMMUNICATIONS WORKING GROUP

An initial review of the lists of facilities for information and communications R & D was performed to identify facilities that would have a low potential for savings. This involved eliminating facilities which had a reported O & M cost of less than \$25 K. The group sees no advantage to consolidation or closure of these facilities.

INFORMATION & COMMUNICATIONS WORKING GROUP

CATEGORY 3A FACILITY INDEX

FACILITY	LOCATION
Cryogenic Optical Test Facility	AMES RESEARCH CENTER, CA
Cryogenics Technology Laboratory	AMES RESEARCH CENTER, CA
HRMS Targeted Search Mobile Research Facility	AMES RESEARCH CENTER, CA
Infrared Detector Technology Laboratory	AMES RESEARCH CENTER, CA
Long-Absorption-Path High-Spectral-Resolution Spec	AMES RESEARCH CENTER, CA
Magnetic Standards Laboratory, 12 Ft. Coil	AMES RESEARCH CENTER, CA
Magnetic Standards Laboratory, 20-Ft coil	AMES RESEARCH CENTER, CA
Meteorological Satellite Downlink and Display System	AMES RESEARCH CENTER, CA
10V Sensor Test Facility	ARNOLD ENGINEERING DEVELOPMENT CENTER, TN
12V Aerospace Chamber	ARNOLD ENGINEERING DEVELOPMENT CENTER, TN
4 X 10 Test Chamber	ARNOLD ENGINEERING DEVELOPMENT CENTER, TN
7A Component Checkout Chamber	ARNOLD ENGINEERING DEVELOPMENT CENTER, TN
7V Sensor Test Facility	ARNOLD ENGINEERING DEVELOPMENT CENTER, TN
Bidirectional Reflectance Dist. Function Chamber	ARNOLD ENGINEERING DEVELOPMENT CENTER, TN
Contaminant Optical Properties (COP) Chamber	ARNOLD ENGINEERING DEVELOPMENT CENTER, TN
High Altitude Observatory (HALO)	BMDO, OK
Space Laser Test Stand (SLTS)	BMDO, CA
System Engineering Laboratory	LANGLEY RESEARCH CENTER, VA
Electronics Laboratory	LANGLEY RESEARCH CENTER, VA
Solid State Laser Development Laboratory	LANGLEY RESEARCH CENTER, VA
Integrated Engineering System	MARSHALL SPACE FLIGHT CENTER, AL
Atmospheric Research Facility	MARSHALL SPACE FLIGHT CENTER, AL
Doppler Lidar Facility	MARSHALL SPACE FLIGHT CENTER, AL
Electromagnetic Interference Test Facility	MARSHALL SPACE FLIGHT CENTER, AL
Magnetic Field Simulation Laboratory	Wallops Flight Facility/GSFC, VA

INFORMATION AND COMMUNICATIONS WORKING GROUP

In general the Information and Communications Working Group found very few facilities that we could not place in other categories. The descriptions, in the NFS data base, of the two 3B facilities on this list did not contain sufficient information to include them in the analysis. And there was not sufficient time to obtain the needed information by other means.

INFORMATION & COMMUNICATIONS WORKING GROUP**CATEGORY 3B FACILITY INDEX**

FACILITY	LOCATION
Microelectronics Research Center	AMES LABORATORY (USDOE), IA
Thermal Vacuum Optical Test Chamber	PHILLIPS LAB / KIRTLAND AFB, CA



Section IV

GENERAL FINDINGS AND RECOMMENDATIONS**IV.A Task Group Findings and Recommendations**

Most of this Space R&D Task Group report has dealt with well-defined groups of individual facilities. This sub-section proposes solutions to more general issues associated with the management of space R&D facilities.

Throughout the course of this study, the Space R&D Task Group — although it was able to compensate in most cases — was hampered by a shortage of information critical to determining the requirements for facilities. The Mission and Requirements Model and facility inventory were two key areas in which information shortages were overcome — but only at great cost in study time and resources. There were other information shortages which the Task Group was not able to adequately redress. The primary example is the lack of a clear understanding of the roles and functions of each of the participants in space R&D. For example, what is the government's role and what is private industry's role? How are the roles of the various government agencies differentiated? How are the roles of major organizations within each government agency differentiated? This lack of a clear understanding of roles — and the inability to adjudicate apparent conflicts and overlaps in roles and missions — ultimately limited the changes the Task Group was able to recommend.

Anyone attempting to manage the nation's space-related facilities will face the same information shortages. This includes agency managers responsible for daily decisions concerning the construction, operation or elimination of facilities. The Task Group developed a number of recommendations that address this issue. If implemented, they would assure those managers have the information needed to effectively manage the U.S. space R&D facilities infrastructure. These include (1) more clearly defining the functions and responsibilities of the major organizations involved in space R&D (to determine which organization should own or manage particular facilities), (2) maintaining a mission model and a key national technologies list, and identifying dual-use R&D opportunities (to determine what requirements the facilities must respond to); and, (3) maintaining a comprehensive facility inventory for both facility managers and facility users. The Task Group also feels that facilities decisions must be made from an interagency perspective and recommends establishment of a space facilities coordination panel. A final recommendation in this area concerns the establishment of a uniform, government-wide pricing policy for the use of test facilities by outside organizations (to facilitate sharing of facilities between agencies and with industry).

The following subsections discuss these recommendations in more detail.

IV.A.1 U.S. Space Functions and Responsibilities**Summary**

Space activities are currently distributed across NASA, DoD, DOE, DOT and DOC. This distribution is the result of historical factors, but should be reexamined in light of changing political and fiscal realities. These new realities include the changing international political scene resulting from the end of the Cold War, developing relations with countries that were part of the former Soviet Union (FSU), increasing emphasis on environmental monitoring and the

proliferation of space-based remote sensing capabilities, and shrinking resources for both military and civilian space programs.

The scope of such a review could include:

- (1) Functions and responsibilities of major organizations within each agency; for example, this would include the respective functions of major Field Centers within NASA and the respective responsibilities among major DoD laboratories involved in space-related activities.
- (2) Functions of entire agencies; for example, the respective responsibilities and activities among DoD, NASA, DOE, DOT and DOC as entities.
- (3) Respective responsibilities of government and private industry; for example, what should be provided by Federal and State government as infrastructure, or other required activities and services, and what should be provided by the private sector.

Such an effort would provide a basis for significant reductions in facilities, personnel and programs by decreasing the space mission overlap within agencies, between agencies, and by clarifying the respective roles of government and private sector organizations. Such a study would require ten persons or more for approximately six months; associated costs of the proposed study cannot be estimated at this time. Cost to implement the recommendations from such a study and the savings that would result are unknown, but would be necessary elements to be estimated during the course of the review.

Findings

General findings include:

- Similar space-related activities are occurring within multiple agencies. These include space-related R&D activities, space launch-related R&D and operations, and on-orbit operations.
- Efforts to coordinate space-related activities within and across agencies are underway, but may not reflect a national perspective on right-sizing government facilities or capabilities. There is a widespread recognition that space-related activities need to become more efficient, but actions typically reflect local perspectives, priorities and approaches, rather than any broadly coordinated strategy.
- Without changes and/or clarification in Agency functions and responsibilities, working groups composed of field representatives and mid-level headquarters personnel will continue to propose recommendations that cannot, in general, address visionary changes or major consolidations. Without direction from the most senior levels, organizations do not naturally recommend the demise of their own functions, organizations and responsibilities, even though such actions could be in the best national interest.

The reasons for an effort to clarify and/or modify agency space functions and responsibilities include:

- Clarification of space-related responsibilities would provide a broader base for precluding unnecessary duplication of space facilities and for making

recommendations for major space facility improvements, consolidations and closures.

- Facilities should follow functional responsibility, especially investment in new capability.
- Recommendations on the use of government facilities by the private sector need to reflect the respective functions of government and industry.
- Clarification of responsibilities among agencies would result in major consolidations and other changes in government space activities (e.g., responsibilities for space-related R&D activities, space launch-related R&D and operations, and on-orbit operations).
- Clarification of responsibilities between government and industry together with a clear national vision and strategy could accelerate the commercial development of space by channeling private investment and intellectual assets into commercially viable activities.
- If the agencies do not take the initiative, Congressional interest and preliminary actions in motion may dictate solutions (e.g., in launch and acquisition).
- Given the current budget environment, a clarification of functions and responsibilities is required, if the U.S. is to have a "world-class" space program. Although the U.S. is the only nation to have put men on the Moon, other nations will overtake us in commercial, civilian government and military space capabilities, if we do not streamline and gain efficiency in our space programs.

Arguments against this effort, include:

- There may be only a limited incentive within various agencies to give up functions and responsibilities. Therefore, a functions and responsibilities study may be too hard to accomplish, or to do well.
- Such a review may be impossible for agencies to initiate on their own, independent of directed budget cuts, because of concern that any consolidation recommendations will take away flexibility to respond to existing cuts.
- Recommendations for organization change can result in self-fulfilling budget cuts; in the current environment, increasing efficiencies may merely lead to a dwindling resources base from which to take still further reductions.
- A recommendation to conduct a functions and responsibilities review could be used as an excuse to delay implementation of other NFS recommendations.
- A redefinition of agency functions and responsibilities could have direct impact on Congressional committee responsibilities, which might be resisted within Congress to the extent that implementation of revised agency roles responsibilities would ultimately be defeated.

Recommendation

To accomplish the proposed effort several steps are recommended. They include actions to obtain Agency head sponsorship, inclusion of other Congressional direction, definition of the parameters of the study, and study team membership. The recommendation is to:

- (1) Seek Secretary of Defense, Secretary of Energy, and NASA Administrator sponsorship of a review of space-related agency roles and functions.
- (2) Incorporate the Administration response to Congressional direction to reorganize DoD space responsibilities into this broader, cross-agency analysis. The fiscal year 1994 DoD Appropriation Report requested an implementation plan for several changes in space organization and management, and the fiscal year 1994 DoD Authorization Bill also directed creation of a Commission on Roles and Missions of the Armed Forces to review and make recommendations on the allocations within the Armed Forces of roles, missions, and functions. One potential area for review will be responsibilities for space-related activities within DoD. The results of these activities assessing DoD responsibilities should be included in a multi-agency review.

IV.A.2 Mission and Requirements Model

The development of a mission and requirements model for use as a basis in determining facilities requirements is discussed in detail in Volume 3 of the NFS final report. The Space R&D Task Group believes that such a model, covering the civilian government, military and commercial space sectors, is required for management of space R&D facilities. The Task Group therefore recommends that this model be maintained and updated at least annually and be made available to all organizations involved in space R&D facilities management.

IV.A.3 Identification of Key National Technologies

An agreed-upon list of key technologies is necessary for a thorough review of national space R&D facilities needs, especially with regard to making recommendations for major future investments in new facilities and capabilities. With declining available resources, the need to establish technology priorities wherever possible is becoming increasingly important; individual agency investment priorities should be grounded in an agreed-upon context of national technology priorities.

The scope of such a list should include key military technologies, key commercial and civilian government space technologies, as well as key dual-use technology opportunities. From the defense perspective, this is especially important because of the growing likelihood that some significant future military capabilities will derive from commercial technologies rather than from DoD R&D activities.

Findings

The reasons for an effort to identify key national technologies include:

- In a period of rapidly declining resources, investments within each agency should take into account the national perspective on key future technologies. Optimizing

scarce investments should be guided from the national level, rather than at the agency level, to avoid sub-optimizing our overall investment.

- The rapid political and technological changes that are occurring dictate that existing programs should not be the only parameter to set the boundaries for future R&D facilities requirements. Constraining future programs to the horizon of merely "doing what we do today, but better" in the face of radical technology growth is a recipe for rapid obsolescence.
- This approach would explicitly recognize the reality of "technology pull" and would focus efforts on high payoff areas. It would take advantage of opportunities for new missions or approaches to satisfy existing needs from new technology developments.
- This approach recognizes that some significant future military capabilities will build on "commercial technologies" rather than on dedicated "military R&D". With the defense "down-sizing" and civil emphasis on commercial R&D and support for international competitiveness, there is growing likelihood that some significant future military capabilities will derive from commercial technologies rather than from dedicated DoD R&D.

There are also arguments not to expend resources in this type of effort.

- In a period of rapidly declining resources, it may not be politically possible to establish priorities. The perception may be that the priorities are merely ways to determine what to cut from the budget; this may be too difficult to overcome.
- The established downsizing process for DoD is tied to force structure, which is not directly linked to R&D levels or priorities. The level of investment in military R&D is not directly determined by the level of our force structure. (For example, deciding whether we have 10 Air Force wings or 20 wings or whether we have 4 or 6 aircraft carrier groups, does not help in structuring the defense R&D program or in justifying a budget level for it.) Because the national consensus to downsize is only — at best — general in nature, there is no consensus on how much we should spend on government R&D. As a result, the best approach may be to make government R&D decisions strictly on a case-by-case basis.

Recommendation

There are several actions to take in identifying key national technologies:

- (1) It is recommended that the White House Office of Science Technology Policy (OSTP) sponsor the creation of a list of key technologies as a part of their existing R&D review processes, which already include space launch R&D. (Because of the national, multi-agency nature of this recommendation, it needs to be done at the White House level.)
- (2) A Terms of Reference (TOR) should be drafted to formalize the scope, participation, uses for the products of the study, and the schedule for this effort. The participating agencies need to participate in the development of the TOR and in formalizing the purposes of the effort.

- (3) The participating agencies should identify candidate members for the study team. Agency members should be senior personnel with technical and programmatic background and adequate authority to speak for their agency as needed.

IV.A.4 Determination of Non-Space Utilization Opportunities

Increasing the value of the U.S. federally-supported R&D infrastructure to the tax-paying public is a key technology policy issue. Although the primary motivation for developing and maintaining space R&D facilities must always remain the missions for which they were conceived, the question of dual-use also applies to space R&D facilities.

As a result, in addition to the OSTP national critical technologies study recommended above, the AACB should also charter a study to examine the NFS inventory and proactively identify opportunities for making U.S. space R&D facilities and capabilities available for the benefit of the U.S. economy through means such as Cooperative Research and Development Agreements (CRDAs), Space Act Agreements (for NASA), and cooperative agreement programs under the Chile's Act.

In order to implement this recommendation, several specific steps are required:

- (1) Senior NASA and DoD management should endorse the study and direct the AACB to conduct it. (The goal of the study should be to examine the NFS inventory and identify opportunities for making U.S. space R&D facilities and capabilities available for the benefit of the U.S. economy.)
- (2) Agency leadership should require a formal Action Plan for implementation of the study, including steps to assure DOE, DOT, and DOC participation, as appropriate.
- (3) The participating agencies should lead the formulation of a TOR for the study, formalizing the purpose, scope, participation, uses for the products of the study, and the schedule for this effort.
- (4) The participating agencies should identify candidate members for the study team. Agency members should be personnel with a background including technical, programmatic and dual-use R&D areas.

IV.A.5 Space Facilities Inventory

A large part of the period over which the NFS was conducted was devoted to developing a computerized aerospace facilities inventory database. The Space R&D Task Group believes the inventory would be very useful for a number of purposes in the future and that it could now be maintained for a relatively modest annual investment, principally using government personnel. An accurate, accessible facilities inventory could improve the efficiency of both government and commercial space programs. For example, a well-maintained inventory could be useful in:

- Locating facilities that may be available to support a program

- Minimizing time spent waiting for specific facilities already in use when other acceptable capabilities may be available
- Preventing the construction of new facilities when existing facilities are available
- Encouraging interactions between organizations operating similar facilities
- Providing a significant head start for future facilities studies

The Task Group recommends that the NFS Oversight Group should request Agency senior management to direct the development and maintenance of a multi-agency aerospace facilities database, built on the foundation established during the NFS. The best course may be for a specific organization to be assigned the permanent responsibility for the facilities inventory and allowed to develop detailed implementation plans as needed.

To accomplish this recommendation, the foundation of the current NFS database should be expanded to include all government facilities, as well as many private sector facilities. Sufficient management endorsement and resources should be devoted to the effort to keep the inventory current over time. In general, this inventory should be made available to a diverse set of U.S. users inside and outside the government.

IV.A.6 Uniform Pricing Policy

Pricing policy for use of government space facilities differs widely across agencies and is implemented in an irregular manner. Policy should be consistent across agencies. Current law requires no more than reimbursement of additive costs for commercial use of space launch facilities, which recognizes the national importance of space activities and the immature state of the U.S. commercial space launch industry. Such an approach should be considered for other space activities, including provisions for the organization providing the service to retain the collected fees.

Current pricing policies include the full range of options, such as:

- No costs - no charges to users.
- Additive costs only - expenses that would not otherwise have been incurred are charged to the external user.
- Direct costs only - additive costs plus all other costs that are easily and directly related to supporting the external user project are charged.
- Indirect costs allowed - direct costs plus costs that are not easily or directly related to the project are charged to the user in addition to direct costs (including an appropriate share of general and administrative overhead, repairs or other costs needed, etc.).
- Full costs - full costs to the government are charged to the user (including costs listed above, plus depreciation, military pay and retirement, etc.).

- Market value - charges to the user are determined by a bid or other contract approach on the basis not of costs to conduct the project, but rather market value of services provided.

A uniform pricing policy would capitalize on government investment in space infrastructure, facilitate competitiveness of U.S. industry by simplifying use of government facilities and reducing industry costs, provide a degree of stability in using government facilities, directly reward the most useful facilities, maintain and/or improve the skills of personnel, provide additional motivation for mutual support arrangements, and reflect that the government is responsible for space infrastructure.

Some of the arguments against a uniform pricing policy include: industry may view it as unfair competition; it may discourage commercial facilities; some resource burden may be shifted to agency budgets; and, it may be inconsistent with moves toward industry funding and full cost recovery.

The following steps must be implemented before a uniform pricing policy is instituted:

- Quantify current pricing practices and estimate costs to make a policy change.
- Identify legal, policy, and procedural changes necessary to implement consistent pricing policies across agencies.
- Identify legal, policy, and procedural changes necessary for agencies to retain collected funds.
- Make specific pricing policy recommendations for space facility use, including whether there should be a different policy for commercial and other U.S. government users.

Agency heads should direct the AACB to develop uniform pricing policy and guidelines for use of government space facilities by other government agencies and by U.S. industry. Actions to include DOE, DOC and DOT in this process should be taken.

IV.A.7 Space Facilities Coordination Panel

The Task Group believes that facilities decisions must be made from an interagency perspective and recommends establishment of a national space facilities coordination panel responsible for providing this perspective. The functions of this panel would include the following:

- Maintain the space facilities inventory discussed in Section IV.A.5.
- Provide assistance to facility users in locating facilities that can meet user requirements.
- When a government agency proposes facility construction or major modifications, provide information on possible alternative means for meeting the agency's requirements using existing facilities.

The Task Group envisions this panel as an advisory body.

IV.B Task Group Recommendation Priorities

The Space R&D Task Group integrated and prioritized the several recommendations made by its working groups and the top-level recommendations of the Task Group itself. This prioritization has been based on three criteria: (1) timeliness of a decision to act (must we get started now?); (2) budgetary impact of the decision to act (potential savings) or delay in decision (additional costs); and (3) national impact of the facility issue/recommendation. In addition, special factors (such as health and safety issues) were considered in assigning priorities.

The following sub-sections summarize the recommendations from the Space R&D Task Group, in order of their priority.

IV.B.1 High Priority Recommendations

The following recommendations were judged to be highest priority by the Task Group:

- Consolidate the eight U.S. liquid propulsion High Pressure Component (turbopump) Test capabilities down to two or three, and stop funding on currently planned improvements until decisions are made regarding the specific approach to this consolidation.
- Downmode A-1/A-2 test positions at the Stennis Space Center
- Conduct a joint government/industry study to reduce the number of active large thermal vacuum chambers and defer construction of any new large thermal vacuum chambers pending this review.
- Conduct a joint government/industry study to determine which two or three liquid propulsion High Pressure Component (Turbopump) Test facilities should be retained.
- Establish a uniform pricing policy for facility usage.
- Consider a review of space functions and responsibilities.
- Maintain a space facilities inventory.

IV.B.2 Medium Priority Recommendations

The following recommendations were judged to be medium priority by the Task Group:

- Consolidate the 300/400 Area at the White Sands Test Facility (WSTF) by taking the 300 Area out of service (also known as "downmoding").
- Reactivate/Upgrade large tri-propellant and hybrid engine test facilities.
- Consolidate all USAF space structures R&D facilities at Phillips Laboratory.

- Replace current generation micro-gravity aircraft.
- Construct a needed new facility for processing composite materials and structures.
- Review spacecraft integration facilities.
- Maintain the current schedule for completion and outfitting of the *DECADE* facility at the AEDC.
- Accelerate availability of the Human-Rated Life Support facility at the NASA JSC by two years.
- Establish a national mission and requirements model.
- Review hypobaric human rated test facility.
- Identify opportunities for dual-use technology R&D support.
- Create a DoD-NASA Space Facilities Coordination Panel.

IV.B.3 Lower Priority Recommendations

The following recommendations were judged to be lower in priority by the Space R&D Task Group:

- Develop needed nuclear propulsion test facility.
- Develop 1-meter cold optics test facility.
- Develop liquid hydrogen structural test facility.
- Consolidate existing human acceleration facilities into a single, world-class advanced motion effects center by 2010.
- Shutdown JPL mirror refurbishment facility.
- Conduct a study directed toward achieving a substantial reduction in the current number of U.S. antenna test facilities.
- Consolidate crop growth facilities.
- Establish a key national technologies list.

IV.C. Integrated Implementation Schedule

Implementation of the several major recommendations of the Space R&D working groups can be phased over the coming decade. Figure 4 provides a summary view of the schedule for these recommendations.

FIGURE 4 – NFS SPACE RESEARCH AND DEVELOPMENT FACILITIES PLAN
MATCHED TO MISSION AND REQUIREMENTS MODEL

	YEAR									
	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03
<div>△</div> CONSOLIDATIONS <div>○</div> UPGRADES										
POWER AND PROPULSION • CONSOLIDATIONS • UPGRADES / NEW		<div>△ 4 5</div>			<div>△ 8</div>				<div>○ 11</div>	
INFO SYSTEMS & COMM. • CONSOLIDATIONS • UPGRADES / NEW	<div>△ 1</div>		<div>○ 6</div>							
HUMAN & MACHINE OPS • CONSOLIDATIONS • UPGRADES / NEW	<div>○ 2</div>									<div>○ 12</div>
MATLS, STRUCTURES & F.D. • CONSOLIDATIONS • UPGRADES / NEW	<div>○ 3</div>		<div>△ 7</div>		<div>△ 9 ○ 10</div>					

2010

NOTES:

- | | | |
|--|------------------------------------|---|
| 1. Close JPL mirror refurbishment facility | 5. Deactivate SSC A-2 | 9. New cold optics facility |
| 2. Human-rated test facility at JSC | 6. Complete AEDC DECADE | 10. New E-beam composites R&D facility |
| 3. New microgravity aircraft | 7. Consolidate USAF structures R&D | 11. Nuclear Thermal Propulsion Facilities |
| 4. Consolidate WSTF 300/400 | 8. Deactivate SSC A-1 | 12. Advanced motion effects R&D center |

IV.D Impact of Requirements Excursions on Findings/Recommendations

IV.D.1. Propulsion and Power

The NFS, space operations and R&D requirements model document (October 1993 edition) identified two excursion missions for the civilian government. Those excursions are the highly reusable vehicle (HRV) and the heavy lift launch vehicle (HLLV). There are several candidate propulsion elements that may be required to support these excursions including large chemical engines, large solid or hybrid motors, and nuclear engines.

The NFS requirements for technology, development and flight support for the chemical, solid, and/or hybrid motors for the excursion vehicles are judged to be largely existing within the facility infrastructure of the United States. This judgment is made with the qualification that modifications to existing facilities are excluded from any definition of facility needs. Consequently, any propellant tanks, thrust structure modifications, instrumentation systems, facility consolidations, etc., may be made to those existing facilities in order to become useful for the excursion missions. It is suggested that these modifications are relatively insignificant considering the 30-year scope of this study.

The facility requirements for nuclear propulsion for an excursion mission may require upgrades to existing and/or construction of new facilities. Since the use of nuclear propulsion elements are not considered to be the leading candidates for excursion vehicles, it is recommended that no capital investments for nuclear facilities be made prior to a national decision regarding missions that might use those technologies.

IV.D.2 Materials, Structures and Flight Dynamics

All of the excursion requirements would certainly have impacts on the utilization and program priorities for the Materials & Structures & Flight Dynamics Facilities. However, the excursion with by far the most impact is the excursion that includes the development of a new space transportation system. Although the working group has stated that the capacity of our present aero/thermal/structural loads facilities are adequate to support a new space transportation system development excursion, certainly most of the facilities would be tied up with development testing. In addition, the two MSFC national facility assets, the Dynamic Test Facility and the Loads Test Annex, would most likely have to be brought up to an operational state. Also, both of the new facilities recommended by the working group were based on the excursion involving the development of a new space transportation system.

IV.D.3 Human and Machine Operations

All of the recommendations from this working group are based on full consideration of both the baseline and excursions in the mission and requirements model, with no adjustments required to accommodate the excursion requirements.

IV.D.4 Information Systems and Communications

The existing Information Systems and Communications facilities are adequate to meet the requirements of the excursions in the mission model (or else the facility development/modification lead times needed would be much shorter than the time required for relevant excursions to mature into actual plans and result in concrete facility requirements).

development/modification lead times needed would be much shorter than the time required for relevant excursions to mature into actual plans and result in concrete facility requirements).

IV.E Other Observations

The following are some additional general observations from the Space R&D Task Group.

Cost Savings. Throughout the study, the Task Group continually found that significant savings can come from not building something or not making proposed modifications, but that closing existing facilities saved very little money unless the government rids itself of the salaries with them. If the government continues the work or uses the people elsewhere, no major savings come from closing a facility. However, the government can be made more efficient by closing or consolidating facilities. Savings from facility closure/consolidation can be even more illusory when, as is often the case, many different facilities are operated by the same people or use the same common support equipment. This must be carefully examined when considering closures or consolidations.

Another general observation is that major cost savings come from not building some space R&D facility rather than from closing one.

Need for Peer Review. As the group reviewed facilities, it noted the lack of peer review of proposed new facilities or major modifications. Unlike agency programs, where independent readiness, peer, and or non-advocate reviews are common, the current system for procuring R&D facilities does not require any review or coordination beyond the facilities community. To remedy this situation, this group recommends that a peer review process be implemented both within and across agency lines.

Environmental Impact Issues. Lastly, with the Environmental Protection Agency imposing increasingly stringent controls on the materials that may be used by industry, this group strongly believes that a plan is needed to develop a capability to conduct Environmental Impact Assessment/abatement research. Since the EPA regulations are impacting all industries, this requirement is not unique to any single working group, to the Space R&D Task Group, or to any particular agency. What such a facility should be, how it should be equipped, where it should be located, etc. are all issues that this group felt were beyond the expertise of its members.

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Section V

DEFINITION OF TERMS, ABBREVIATIONS AND ACRONYMS**V.1 Glossary of Acronyms**

AA	(NASA) Associate Administrator
AACB	Aeronautics and Astronautics Coordinating Board
AEDC	(USAF) Arnold Engineering Development Center
AFSPACECOM	Air Force Space Command
AL	(USAF) Armstrong Laboratory
ARC	(NASA) Ames Research Center
ARPA	Advanced Research Projects Agency
BMDO	Ballistic Missile Defense Organization
CoE	Corps of Engineers
COF	Construction of Facilities
COMSTAC	Commercial Space Transportation Advisory Committee
CRV	Current Replacement Value
DECADE	Refers to ten times (10x) the current capability
DOC	Department of Commerce
DoD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
DSN	Deep Space Network
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
ESA	European Space Agency
EVA	Extravehicular Activity
FAA	(DOT) Federal Aviation Administration
FTE	Full Time Equivalent
G	Gravity (standard measure of acceleration)
GaAs	Gallium Arsenide
GEO	Geostationary Earth Orbit
GN&C	Guidance, Navigation and Control
GPS	Global Positioning Satellite
GSFC	(NASA) Goddard Space Flight Center

HALO	High-Altitude Observatory
HELSTF	High-Energy Laser Systems Test Facility
HRMS	High Resolution Microwave Spectrometer
HRV	Highly Reusable Vehicle
IOC	Initial Operating Capability
IR	Infrared
JCS	Joint Chiefs of Staff
JDL	Joint Directors of Laboratories
JPL	(NASA) Jet Propulsion Laboratory
JSC	(NASA) Johnson Space Center
KMR	Kwajalein Missile Range
KSC	(NASA) Kennedy Space Center
LaRC	(NASA) Langley Research Center
LEO	Low Earth Orbit
LeRC	(NASA) Lewis Research Center
MFPE	Mission From Planet Earth
MLV	Medium Launch Vehicle
MSFC	(NASA) Marshall Space Flight Center
MTPE	Mission To Planet Earth
NACA	National Advisory Committee on Aeronautics
NASA	National Aeronautics and Space Administration
NDE	Non-Destructive Evaluation
NFS	National Facilities Study
NIST	(DOC) National Institute of Standards and Technology
NOAA	National Oceanographic & Atmospheric Administration
NORAD	North American Air Defense
NSF	National Science Foundation
O&M	Operations and Maintenance
OA	(NASA) Office of Aeronautics (a.k.a. Code R)
OACT	(NASA) Office of Advanced Concepts & Technology (a.k.a. Code C)
OCST	(DOT) Office of Commercial Space Transportation
OLMSA	(NASA) Office of Life & Microgravity Science and Applications (a.k.a. Code U)
OSTP	Office of Science and Technology Policy
OSF	(NASA) Office of Space Flight (a.k.a. Code M)
OSS	(NASA) Office of Space Science (a.k.a. Code S)

OSSD	(NASA) Office of Space Systems Development (a.k.a. Code D)
PL	(USAF) Phillips Laboratory
POC	Point of Contact
R&D	Research and Development
R&F	Roles and Functions
R&T	Research and Technology
RF	Radio Frequency
RTOP	(NASA) Research and Technology Operating Plan
SAF	Secretary of the Air Force
SEARWG	Systems Engineering and Requirements Working Group
SIRTF	Space Infrared Telescope Facility
SRB	Solid Rocket Booster
SSTO	Single Stage To Orbit
SSTO (R)	SSTO (Rocket Propulsion)
STIG	Space Technology Interdependency Group
TOR	Terms of Reference
TPS	Thermal Protection System
USA	U.S. Army
USAF	US Air Force
USAF/TE	USAF/Test and Evaluation
USN	US Navy
UV	Ultraviolet
VLSI	Very Large Scale Integration

V.2 Definitions of Selected Terms

Abandoned	Building is out of service and stripped, but could be refurbished.
Communications	Specific communications lines to support automated data processing capabilities. Considers costs for local area networks, dedicated communication lines, fiber optics, etc.
Downmoded	Building is out of service with minimum maintenance.
Energy	Costs of utilities to operate a facility or system. Categories of costs include: architectural, mechanical, electrical, high-voltage AC, and control systems.
Environmental Costs	Costs associated with compliance that are recurring, such as pollution prevention and permits.
Equipment Outfitting Maintenance	Costs of day-to-day work required to preserve the equipment in such a condition that it may be used for its designated purpose over its intended service life. Categories of costs include: preventative and predictive testing and inspection, repair, programmed maintenance, trouble calls, and replacement of obsolete items.
Facility Maintenance	Costs of day-to-day work required to preserve a facility or system in such a condition that it may be used for its designated purpose over its intended service life. Categories of costs include: preventative and predictive testing and inspection, repair, programmed maintenance, trouble calls, replacement of obsolete items, ground care, central utilities, ground operations and maintenance.
Moth Balled	Building is out of service with no maintenance.
Operations	Costs associated with the day-to-day activities of a facility and its outfitting. Categories of costs include: off-site leasing, custodial, security, utilities (water, sewer, etc.), contractor support for equipment operations, and furniture/fixtures.
World Class	One which is known to be preeminent in its field. It is an effective combination of physical facilities/equipment, a skilled and dynamic work staff, a clearly defined mission, and an outstanding product.
Magnet Class	One with unique capabilities which compel the customer to select without regard to facility or customer affiliation. Usually one-of-a-kind, and/or world class.

Section VI

LIST OF FIGURES AND TABLES

The following is a list of the figures and tables depicted in this report.

VI.A Figures

- Figure 1 Summary diagram of the organization of the Space R&D Task Group
- Figure 2 Summary timeline for the implementation of key Space R&D Task Group recommendations
- Figure 3 Space R&D Facilities Study Methodology
- Figure 4 Summary timeline for the implementation of key Space R&D Task Group recommendations

VI.B Tables

- Table 1 Space R&D Task Group facility inventory summary
- Table 2 Space R&D Task Group consolidation (Category 1A) recommendations and/or endorsements
- Table 3A Space R&D Task Group Summary of Recommendations (Part A)
- Table 3B Space R&D Task Group Summary of Recommendations (Part B)
- Table 3C Space R&D Task Group Summary of Recommendations (Part C)
- Table 4 Space R&D Task Group Facility Findings (top-level statistics)
- Table 5 Space R&D Task Group Facilities Findings (statistics by working group)

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Appendix A

STUDY TERMS OF REFERENCE (TOR)**A.1 National Facilities Study TOR****1. BACKGROUND**

The United States is increasingly challenged by advances in technologies that will affect its global competitiveness in virtually all economic sectors. Preeminent among these are advances in aerospace technology. These advances are paced by modern highly productive research, development, and operational facilities. Recognizing this situation, on November 13, 1992, the NASA Administrator initiated the development of a comprehensive and integrated long-term plan for future aerospace facilities. This integrated plan would be accomplished in partnership with other Government agencies, industry, and academia to ensure that the facilities are world-class and to avoid duplication of effort. He contacted top officials in the Departments of Defense, Energy, Transportation, Commerce, and the National Science Foundation inviting them to participate in the development of the plan and the appropriate working groups. The Administrator proposed an Oversight Group chaired by John R. Dailey, NASA Associate Deputy Administrator, with representation from DoD, DOT, DOE, DOC, and the NSF. Each of the agencies responded with nominations of individuals to serve on the Oversight Group and provide support on Task Groups to establish detailed plans. This Terms of Reference document provides the coordinated charter for development of the Aerospace Facilities Plan.

2. PURPOSE

To formulate a coordinated Nation Plan for world-class aeronautical and space facilities that meets the current and projected needs for commercial and Government research and development, and for Government and commercial space operations.

3. SCOPE

The plan will include a catalog of existing Government and industry facilities that support aeronautics and astronautics research, development, testing, and operations. International facilities will also be cataloged to determine capability relative to U.S. facilities and applicability to address U.S. facility shortfalls.

The plan will include a requirements analysis which will consider current and future Government and commercial industry needs as well as DoD and NASA mission requirements, through the year 2023, and specifically will address shortfalls in existing capabilities, new facility requirements, upgrades, consolidation, and phase out of existing facilities. All new facility requirements and upgrades will be prioritized and detailed schedules and total funding will be specified.

Joint management schemes, life cycle costs, and siting requirements will be fully evaluated.

Joint funding between agencies and Government/industry will be considered. Shared usage policies will be developed where nonexistent.

Costing, definitions, evaluation methodology and dollar threshold for facility inclusion in review will be approved by the Oversight Group.

4. ORGANIZATION

An Oversight Group, chaired by NASA with a DoD Vice-Chairman and including membership from DOE, DOT, DOC and the National Science Foundation, will have responsibility for implementing this TOR and plan development. The secretary will be nominated by NASA.

The chairman will appoint a study director for executing this TOR. This person will be responsible for conducting the study and its schedule, coordinating participation, integrating all inputs, preparing the final products, and providing those products to the Oversight Group.

To assist the study director, four task groups will be established. These are the Aeronautics R&D Task Group, the Space R&D Task Group, the Space Operations Task Group and the Facilities Costing and Engineering Group. The task groups will be co-chaired by NASA and DOC. All participating agencies will provide representatives to each task group. The task groups will have the authority to establish working groups to assist them in their tasks. Membership on the task and working groups will be limited to Government employees and participation is optional, except for NASA and DoD. The Aeronautics Task Group is an exception because of the special need to address commercial transport aircraft. For this reason experts from private industry participate as Special Government Employees, and the task group will function in accordance with the Federal Advisory Committee Act. Throughout the study, however, industry and academic inputs and advice should be actively solicited.

The Oversight Group will provide guidance to the task groups, serve as the coordination mechanism, perform periodic progress reviews, resolve disputes or misunderstandings that may arise between the agencies under the memorandum, and recommend an integrated plan for agency approval. The task groups will have responsibility for planning, directing, and providing recommendations in their particular discipline area.

Each agency will utilize its own reporting and tasking authority and will bear its and its employees' own costs for participation. Activities shall be subject to the availability of funds and personnel of each party.

5. PRODUCT

The study director will provide a summary report to the Oversight Group incorporating input from each of the task groups that includes a compendium of current facilities and capabilities; identification of shortfalls as a function of current and projected needs; and recommendations and rationale for new facilities, upgrades, consolidation, or closure of existing facilities. Recommendations will include cost impacts, either as investment costs or savings, and any other considerations that would bear on the decision (i.e., national security concerns, technology transfer, proprietary data rights, commercial competitiveness, etc.). The summary report will also include any recommendations relative to a policy nature, such as shared usage, common costing, and management and operation.

Upon approval by the Oversight Group, each report will be forwarded for agency approval. Final reports will be approved at the Deputy Administrator/Under Secretary level or equivalent. For the DoD the responsible authority is the Under Secretary of Defense for Acquisition. Final reports should reflect a national viewpoint endorsed by NASA, DoD, DOC, DOT, DOE and NSF.

6. SCHEDULE

Interim Task Group Reports	July 1993
Final Task Group Reports	January 1994
Oversight Approval - Task Group Reports	February 1994
Coordination of Individual Reports	March 1994
Approval of Individual Reports	March 1994

7. APPROVAL, AMENDMENT, AND TERMINATION

This Terms of Reference shall enter into force upon the signature of all Parties and shall remain in force through July 1994. It may be modified, extended, or terminated by mutual consent of all parties.

Original Approved by:

Department of Commerce, David Barram, Deputy Secretary

Department of Defense, William J. Perry, Deputy Secretary

Department of Energy, Bill White, Deputy Secretary

Department of Transportation, Mortimer L. Downey, Deputy Secretary

National Aeronautics and Space Administration, Daniel S. Goldin, Administrator

National Science Foundation, Neal Lane, Director

A.2 Space R&D Facilities Task Group TOR

1. BACKGROUND

The Administrator of the National Aeronautics and Space Administration (NASA) and the Deputy Secretary of the Department of Defense (DoD) agreed to enter into a joint study to develop a comprehensive and integrated long-term plan for future world-class aerospace facilities. Subsequent to that agreement, the Departments of Commerce, Energy, and Transportation and the National Science Foundation have agreed to participate. The plan will address current capabilities and projected government and industry aeronautics and space facility needs through 2023 and, when appropriate, make recommendations relative to development of new facilities or enhancement and consolidation of existing facilities.

This NASA-DoD Joint Facility Study is divided into four Task Groups, addressing Aeronautics Research and Development (R&D) Facilities, Space R&D Facilities, Space Operations Facilities, and Costing and Engineering. This TOR addresses the Space R&D Facilities Task Group and is derived from the Terms of Reference for the National Plan.

There are inherent institutional differences between aeronautical and space facilities. National security space activities and associated facilities have predominately been driven by and dedicated to supporting specific space systems. Space R&D facilities tend to be embedded within broad R&D capabilities, some of which have application to space missions as well as other areas. While the possibility for shared facility usage is less probable in these space activities than in aeronautics, given shrinking budgets, we need to exploit opportunities for consolidation and sharing of facilities where appropriate. A detailed assessment and a long term plan for future space R&D facilities can provide a roadmap to assist us in identifying the opportunities for gaining efficiencies through multi-use and shared facilities as we continue to build our nation's space R&D capability.

2. PURPOSE

To determine the capability of national and international space R&D facilities to meet future space R&D requirements and, to formulate a coordinated national plan for world-class space R&D facilities that meets the current and projected needs for commercial and government space-related research and development. International space R&D facilities will also be cataloged to determine capability relative to U.S. facilities and applicability to address U.S. facility shortfalls.

3. SCOPE

Space R&D facilities involve all facilities that currently support or are planned to provide major research, development, test, and production support to space activities. Mission-unique national security space R&D facilities dedicated to supporting national security activities may be beyond the scope of this study. The sponsoring organizations for those facilities will be the sole authority for determining if such facilities shall be included.

4. APPROACH

The Space Research and Development Facility assessment will include the following six tasks.

Task 1: Develop criteria for what constitutes a major space R&D facility. The criteria will allow identification of DoD, NASA, and industry human and machine operations, materials, structures and flight dynamics; power and propulsion, and information and communications facilities that are within the scope for the study as defined above.

Task 2: Develop and benchmark world-class standards for major space R&D facilities. The standards will provide the basis for developing a national plan for future world-class facilities.

Task 3: Identify current and projected mission needs that drive facility requirements. The mission needs will also provide the basis for developing a national plan.

Task 4: Inventory major government and industry space R&D facilities in accordance with the criteria defined in Task 1. Catalog facilities as functions of mission need(s).

Task 5: Assess mission requirements, facilities shortfalls, and excess capacity; recommended actions to include a long-term national plan.

Task 6: As appropriate, develop options, recommendations, and an action plan (i.e., a long-term plan) as required for Oversight Group review and approval.

5. ORGANIZATION

The Space R&D Task Group will be co-chaired by Dr. Peter Lyman (NASA) and Mr. Dennis Granato (DoD). To support the efforts of the Task Group, Working Groups may be established upon approval of the co-chairmen. Those Working Groups will also be co-chaired by DoD and NASA. The following Working Groups have been constituted:

- Systems Engineering and Requirements
- Strategy and Policy
- Human and Machine Operations
- Materials, Structures and Flight Dynamics
- Power and Propulsion
- Information and Communications

Systems Engineering and Requirements Working Group

This working group has responsibility for establishing guidelines for the other technical working groups and defining the facility inventory format, cataloging data needed, integrating inputs from the other working groups, and reconciling commonality or duplications in R&D needs or facilities between the other working groups.

Strategy and Policy Working Group

This working group, which will support both the Space R&D and Space Operations

Task Group, has the responsibility for integrating program facility needs in their specific discipline areas related to R&D, evaluating the appropriate facilities to meet those needs, and recommending changes where appropriate.

Other Working Groups

The remaining working groups have responsibility for integrating program facility needs in their specific discipline areas related to R&D, evaluating the appropriate facilities to meet those needs, and recommending changes where appropriate.

6. PRODUCT

The Space R&D Task Group will submit a summary report to the Oversight Group, in the form of a plan, that includes a description of current and future mission needs, a catalog of current facilities and capabilities, identification of shortfalls in each of the discipline areas, and recommendations, with supporting rationale. Information associated with each recommendation will be consistent with that specified in the TOR for the National Plan.

7. SCHEDULE

TOR Approval	July '93
Facility Inventory Complete	August '93
Requirements Assessment	July '93
Preliminary Plan	September '93
Brief Oversight Group	October '94
Final Plan (Task Group Approval)	January '94
Final Report to Oversight Group	February '94

Approved:

ORIGINAL SIGNED BY
P. LYMAN

NASA Co-chair
Space R&D Facility Task Group
July 15, 1993

ORIGINAL SIGNED BY
D. GRANATO

DoD Co-Chair
Space R&D Facility Task Group
July 15, 1993

Appendix B

PARTICIPANTS LIST

The following lists summarize the major participants in the NFS Space R&D Facilities Task Group and Working Groups.

B.1 Space R&D Task Group

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ORIGINAL PAGE IS
OF POOR QUALITY

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B.8 Strategy and Policy Working Group (joint with Space Operations)

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Appendix C

LIST OF REFERENCES

The following are selected references used in the conduct of the Space R&D Task Group's efforts and the development of the group's report.

C.1 Working Group Letter Reports

In addition to the work presented in this document, several of the technical working groups of the Space R&D Facilities Task Group of the NFS prepared letter reports for the record. These reports, cited below, provide additional information on selected topics of special interest. (The reader of this document is encouraged to obtain a copy if additional detail in these technical areas is desired.)

R. Corley and N. Hannum, "Letter Report from the Propulsion and Power Working Group"; NASA Internal Memorandum. April 1994.

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C.2 General References

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